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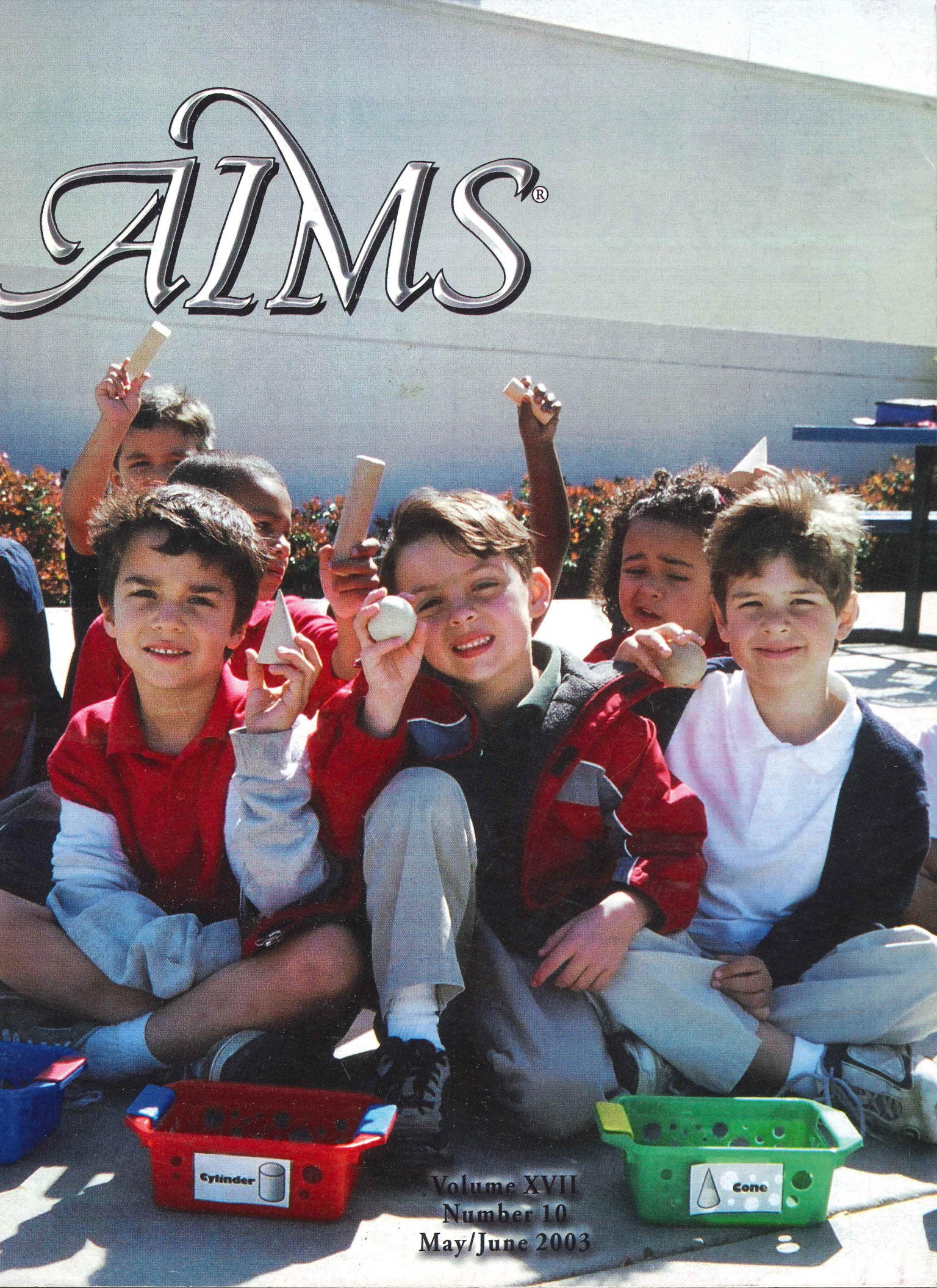

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email: aimsed@aimsedu.org

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On the cover: Students from Mrs. Fitzgerald's class participate in the activity *Solid Shape Relay.*

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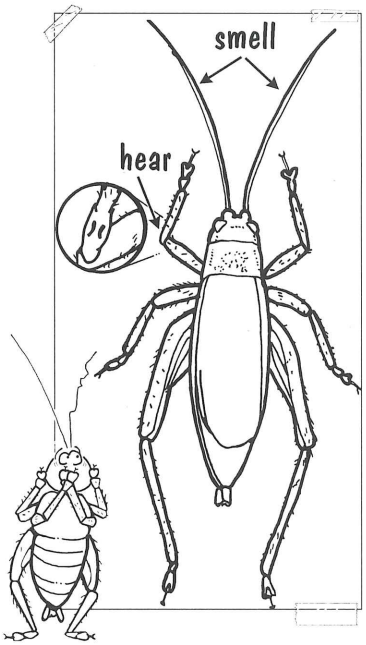
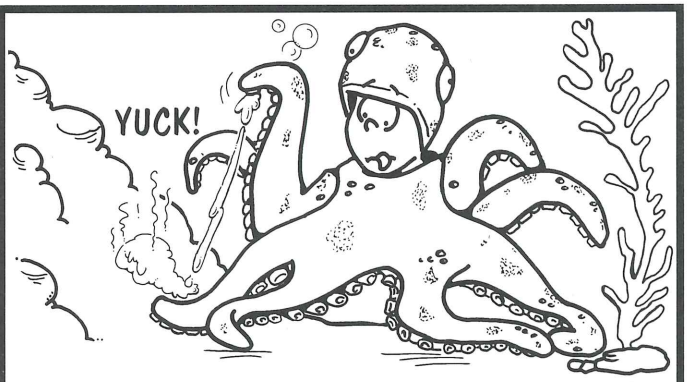
Isn't It Interesting...
Strange Senses

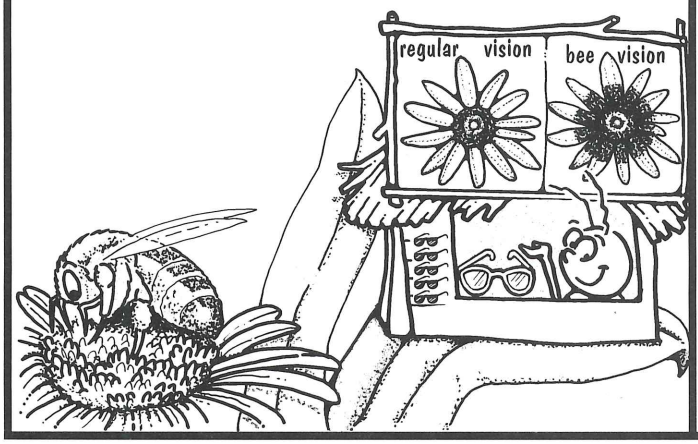
Crickets don't have ears or noses the way people do. They hear with special membranes on their legs and smell with their antennae.

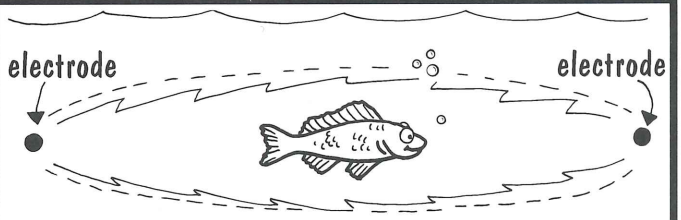




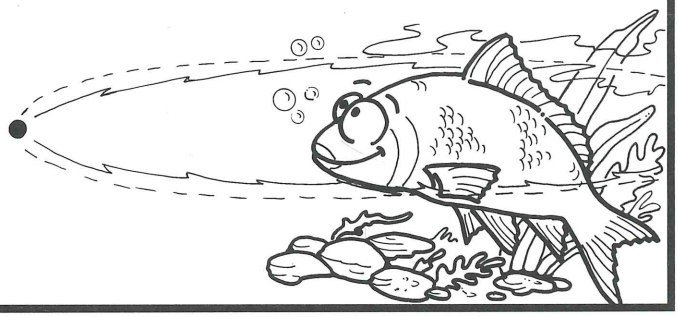
Octopi have their taste buds (chemoreceptors) on the suction cups of their tentacles. Their retinas contain only about 20 million light-detecting receptors (photoreceptors), compared to about 126 million in humans.

Bees can see ultraviolet light with wavelengths as low as 300 nanometers. This makes colors appear differently to them than to humans—grass becomes red; red flowers look black. It also allows them to see special patterns on some flowers that are only visible in ultraviolet light.





Most fish have the ability to generate an electric force field. This field bounces off solid objects, but not plants, allowing fish to better sense their surroundings.



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Making Sense of Crickets

by Myrna Mitchell

Topic
Characteristics of animals

Key Question
How does a cricket sense its world?

Learning Goals
The students will:
1. identify how a cricket senses its world, and
2. compare their senses to those of a cricket.

Guiding Documents
Project 2061 Benchmarks
- *People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.*
- *Describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.*
- *A lot can be learned about plants and animals by observing them closely, but care must be taken to know the needs of living things and how to provide for them in the classroom.*
- *Plants and animals have features that help them live in different environments.*
- *Different plants and animals have external features that help them thrive in different kinds of places.*
- *Most living things need water, food, and air.*

NRC Standards
- *Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments, and distinct environments support the life of different types of organisms.*
- *Each plant or animal has different structures that serve different functions in growth, survival, and reproduction. For example, humans have distinct body structures for walking, holding, seeing, and talking.*
- *The behavior of individual organisms is influenced by internal cues (such as hunger) and by external cues (such as a change in the environment). Humans and other organisms have senses that help them detect internal and external cues.*

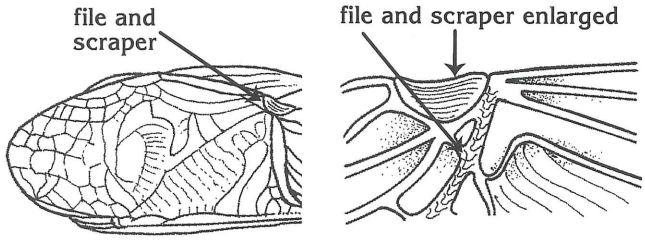
Science
Life science
animal characteristics

Integrated Processes
Observing
Predicting
Collecting and recording data
Comparing and contrasting

Materials
For the class:
My Five Senses by Aliki (see *Curriculum Correlation)*
A Pocketful of Cricket by Rebecca Caudill (see *Curriculum Correlation)*
A Very Busy Cricket by Eric Carle (see *Curriculum Correlation)*
crickets (see *Management 1)*
terrarium (see *Management 2)*
chart paper
popcorn and popper (see *Management 4)*
apples
stapler

For each student:
cricket journals

Background Information
Humans have been fascinated by crickets for many years. Cricket images even appear in ancient cave drawings. People seem most intrigued with the cricket's song. These songs come from male crickets, which have sound-producing organs on their front wings. Males rub their wings together to produce that chirp you hear at night. But they are not just chirping to make the quiet night go by; they are trying to attract females.



On the left is a portion of the cricket's wing. On the right, the sound-producing organs are enlarged. Each wing has a "file," or thickened vein with cross-ridges, and a "scraper" or hard, sharp-edged spot. The scraper of one wing is rubbed against the file of the other wing to produce the cricket song.

A cricket is an insect. Insects have three main body parts, six legs, and antennae. A cricket has

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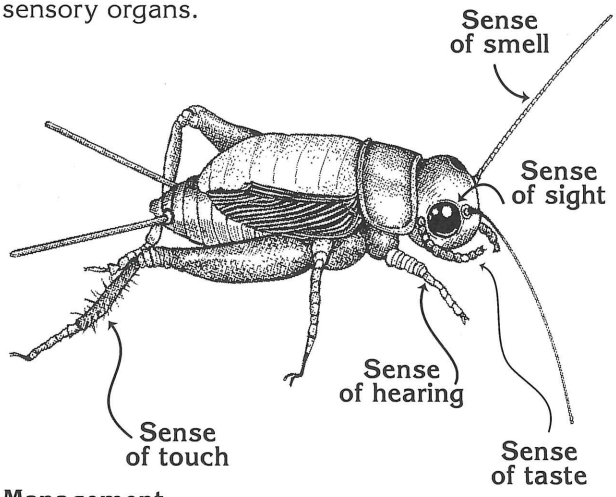
two pairs of legs that it can walk with, and one pair that are longer for jumping. Unlike its cousin the grasshopper, the cricket tends to be dark brown or black. Crickets also tend to be more active at night, although they may be seen during the day. The field cricket is one of the most common insects in North America. There are several species of field crickets ranging in size from 1/4 to 3/4 inch, but the most common is the black field cricket, a large, shiny black insect. Unlike house crickets, field crickets spend most of their life outdoors where they feed, grow, develop, and reproduce.

Field and house crickets are ideal animals to study for many reasons. They are small and easily raised, they perform some interesting behaviors, and they use sound to manipulate the behavior of others.

Crickets see with their eyes, smell with their antennae, hear with tympana on their legs, taste with taste bud-like structures on their palps, and feel or touch with tiny hairs all over their bodies, particularly on their cerci. Cerci are a pair of simple or segmented appendages at the posterior end that usually act as sensory organs.



Management

1. Crickets can be easily collected in the field or they can be purchased at most live bait shops as well as pet stores.
2. An old aquarium makes a good home for crickets. Keep two or three inches of sand or soil in the aquarium. Crickets eat small wet pieces of bread, moistened circular oat cereal, lettuce, and carrots. To provide water, simply spray the glass with a water bottle once a day. Make sure you have a secure lid for the top. A screen works well.
3. Student individual observation containers can be constructed by cutting the tops off clear two-liter bottles and using the base. A secure top can be constructed out of cheesecloth that has been cut a little larger than the top of the bottle opening and draped over the hole.
4. A hot air popper is best so that the students will be able to hear the popcorn popping.

Procedure

Part One

1. Read *My Five Senses* by Aliki. Ask the students to name some things that they like to do. Record their responses on chart paper.
2. Choose several items from the list and discuss what senses are used in those activities.
3. Pop some popcorn in class. Have the students eat popcorn. While popping and eating popcorn, discuss the senses students are using, where sense organs are located, and what they are experiencing using each sense organ.
4. Discuss other things that the students like to do.
5. Distribute the student pages and assist students in making their cricket journals. The third student page (with the cricket diagram) goes on top, facing up, the first student page (the front and back covers) goes on the bottom, face down, and the second student page goes in between the two, facing up. Fold the papers in half along the dashed lines and staple all three papers together as close to the edge as you can.
6. Have the students record two different activities and what senses they use when doing those activities on the two *Sensing My World* pages.
7. Have the students share their work.

Part Two

1. Read *A Pocketful of Cricket* by Rebecca Caudill. Have the crickets nearby in a terrarium. Encourage the students to respond to the story. Lead their responses with questions such as "Has this ever happened to you?" "What do you think?" etc.
2. In small groups, have the students observe crickets in the terrarium. Have them use the blank pages in their journals to record any evidence of crickets having senses.
3. As a class, share observations and predictions from the journals.
4. Place a piece of popcorn and apple slices in the terrarium to stimulate the crickets' use of their sense organs. Observe and record what happens with the food added to the terrarium.

Part Three

1. Ask the students how they think crickets sense their world.
2. Read *A Very Quiet Cricket* by Eric Carle.
3. Explain that crickets see with their eyes, smell with their antennae, hear with tympana on their legs, taste with taste bud-like structures on their palps, and feel or touch with tiny hairs all over their bodies, particularly on their cerci (see *Background Information).* Use an overhead or an enlarged diagram to convey the information.

(See CRICKETS, page 14.)

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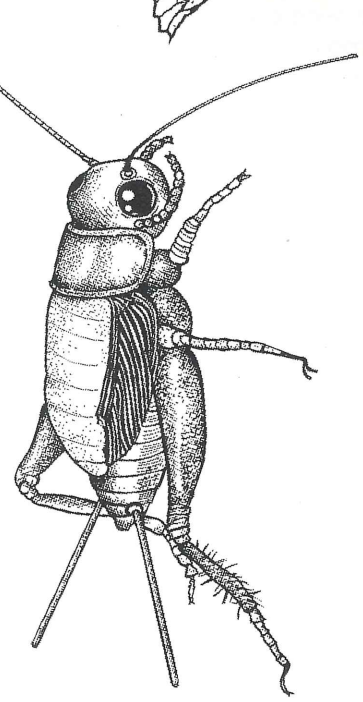
Cricket Journal



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Sensing my world

I like to _____.

When I _____ I use my sense of:
(circle the one you use)

Touch

Hearing

Smell

Taste

Sight

How are your senses the same as a cricket's?

_____

_____

_____

_____

How are they different?

_____

_____

_____

_____

_____

_____

Sensing my world

I like to _____.

When I _____ I use my sense of:
(circle the one you use)

Touch

Hearing

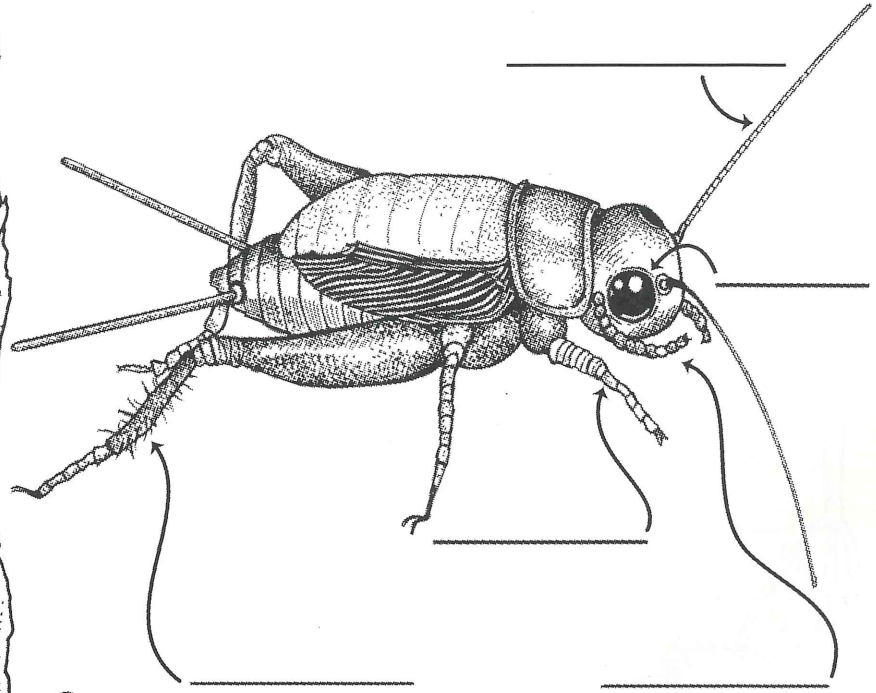
Smell

Taste

Sight

Cricket Observation Sheet

Where does a cricket see, taste, touch, feel, smell?



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Numbers in Orbit: Part Two

by Richard Thiessen

Looking for number patterns provides a way to take students beyond arithmetic, beyond simply memorizing number facts and becoming proficient with the algorithms for addition, subtraction, multiplication, and division. As important as it is that students be proficient in arithmetic, if we want them to develop an enjoyment and excitement about mathematics, if we want them to know and care about numbers, we must take them beyond memorization, practice, and simple story problems. One way to do that is to engage them in the search for patterns. That search may sometimes be simply generating lists of numbers and looking at the lists for repeated sequences of numbers. This is not so unlike the AABAABAAB... type patterns that children experience in kindergarten. Often the number patterns can be represented visually to better reveal the structure of the pattern and make it easier to compare one pattern to another.

As students generate the patterns described in this article, there are abundant opportunities to practice their multiplication facts and focus on a particular place value. While the first article of this series focused on sums of evens and odds, this article will focus on products of even and odd numbers. Repeating sequences of numbers will be called orbits and will be presented visually by being placed on the circumference of a circle so that from a starting number, the repeating pattern is encountered over and over again as you move around the circle from number to number.

Just as we did in the earlier article, we will begin by looking at patterns in the units place of the numerals. In the next and final article of this series we will come back to look for patterns in the tens and units places taken together.

In the first article, we looked for patterns in lists where we started with a given number and then generated successive numbers in the list by repeatedly adding another number. For example, we started with the number 3 and then generated the successive numbers in the list by repeatedly adding the number 2.

3, 5, 7, 9, 11, 13, 15, 17, 19, 21...

If we only record the units digit of the number, we have the repeating sequence:

3, 5, 7, 9, 1, 3, 5, 7, 9, 1...

Had we started with 7 instead of 3, our sequence would have been:

7, 9, 1, 3, 5, 7, 9, 1, 3, 5, 7 ...

We could have started a list with any one of these five odd numbers. The numbers and the order of the numbers in these repeating patterns are always the same, only the starting point is different. This is why it is so natural to represent these patterns as numbers orbiting around the circumference of a circle. The patterns we have just

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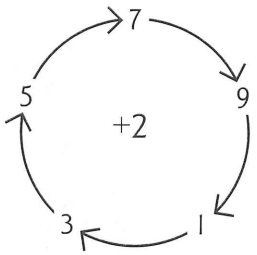
described involve starting with an odd number and generating each successive term of the sequence by adding 2. If the orbit is launched from the number 5, the repeating sequence is encountered by simply moving around the circle in a clockwise direction.



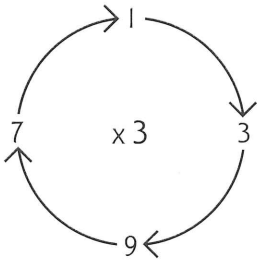
The focus of this article is to begin to explore lists that are generated by repeated multiplication. We will be given two numbers. A starting number and the multiplier number. For example, suppose we start with 7 and repeatedly multiply by 3. This would generate the following list of numbers.

7; 21; 63; 189; 567; 1701; 5103; 15,309…

If we only record the digit in the units place, we have the following repeating pattern:

7, 1, 3, 9, 7, 1, 3, 9…

The numbers in the sequence get large quickly, much faster than they did when we were adding. But it doesn't really matter because we only want to pay attention to the units place. This means that we only need to multiply the units place digits to generate the sequence. The sequence of units place digits then has an orbit that is simply the repeating of the digits 7, 1, 3, 9. Had the starting number been 1 instead of 7, the sequence of repeating digits would be 1, 3, 9, 7. The times-3 orbits for starting numbers 1, 3, 7, and 9 can be represented on the circumference of a circle as seen to the right.



Notice in these orbits that we started with an odd number in each case, and 3, our multiplier, is also an odd number. An odd number times an odd number is odd.

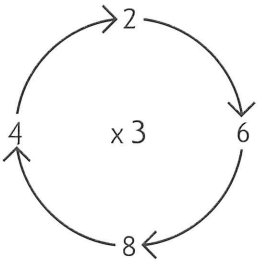
Suppose we had started with 2, an even number, and kept 3 as our multiplier number. The first several numbers of this sequence would be:

2, 6, 18, 54, 162, 486, 1458, 4374…

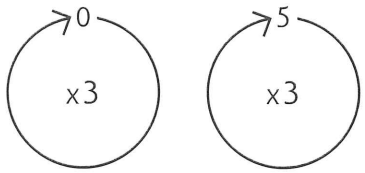
and the pattern of units digits is as follows:

2, 6, 8, 4, 2, 6, 8, 4…

In this case we started with an even number, but the multiplier number—3—is odd. An even times an odd is always even, so the numbers generated in the sequence must all be even. The times-3 orbits for starting numbers 2, 4, 6, and 8 can be represented on the circumference of a circle in the following way.



Note that 0 and 5 have so far not appeared as starting numbers. If 5 is the starting number and 3 is the multiplier, all of the numbers in the list will be multiples of 5 and so the sequence is simply a list of 5s. Similarly, if 0 is the starting number, the sequence will contain only 0s.



Suppose the multiplier number is an even number such as 2. Since an even times an even is even and an even times an odd is even, the orbits must always be even numbers. Let's try some things to generate a couple of sequences to see what happens. Suppose the starting number is 6. The sequence of units digits would be:

6, 2, 4, 8, 6, 2, 4, 8, 6…

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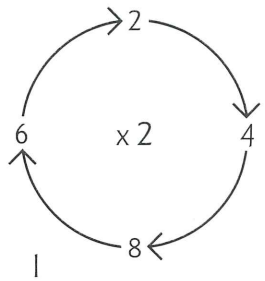
Similarly, had we started with 4, the sequence would be:

4, 8, 6, 2, 4, 8, 6, 2, 4...

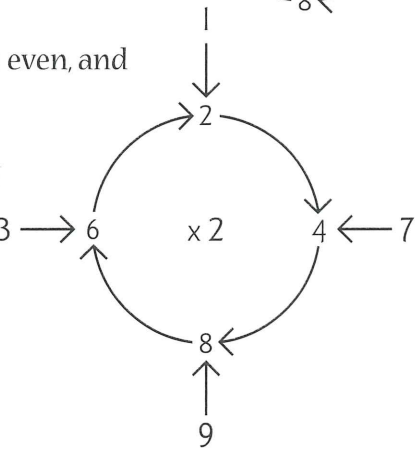
These orbits can again be represented by placing the sequence of numbers around the circumference of a circle.



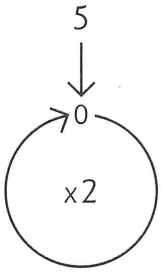
What happens when 2 is the multiplier and we start with an odd number? For example, suppose we start with the number 3. Look at the sequence that is generated.

3, 6, 2, 4, 8, 6, 2...

The explanation, of course, is that an odd times an even is even, and since our multiplier is even, each term after the first must be even. This same thing will happen for each of the odd numbers, except for 5, where something special happens. We can represent the situation with the odd numbers by showing that they start outside an orbit, but then quickly, within one term, go into orbit.



If our starting number had been 5, the next number of the sequence would be 0 and every number in the sequence after that would also be 0. This situation can be represented by starting with 5 outside of an orbit and then immediately going into the orbit containing only the number 0.



I want to challenge you to try this idea using each of the numbers 1 through 9 as multipliers and using the numbers 1 through 9 in turn as the starting number. It is absolutely fascinating to see the different orbits that are generated in this way. For example, I was surprised at the way the orbits turn out when 4 and 6 are the multipliers. Generating the orbits provides students with multiple opportunities for practicing the multiplication facts in a way that has the added benefit of being self-checking. Moreover, it provides multiple opportunities to think about multiplication of even and odd numbers. The final article in this series will focus on 3 and 7 as multipliers, but instead of looking only at the units digit, we will look at sequences of two-digit numbers generated in the units and tens places.

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by Ann Wiebe

Topic
Concept of averages: median and mean

Key Question
What is the typical word length?

Focus
Sets of color synonyms provide the data from which students will identify and compare the median, mean, and spread.

Guiding Documents
Project 2061 Benchmark
- *Spreading data out on a number line helps to see what the extremes are, where they pile up, and where the gaps are. A summary of data includes where the middle is and how much spread is around it.*

*NCTM Standards 2000**
- *Describe the shape and important features of a set of data and compare related data sets, with an emphasis on how the data are distributed*
- *Use measures of center, focusing on the median, and understand what each does and does not indicate about the data set*

Math
Data analysis
averages (measures of center)
median
mean
spread
Ordering
Line plot

Literacy
Vocabulary development
synonyms for primary colors

Integrated Processes
Observing
Comparing and contrasting
Interpreting data

Materials
Dictionaries
1-cm graph paper or the grid provided
Scissors
Glue or tape
Lima beans or blocks

Background Information
Measures of Center

A key aspect of data is where it is *centered*. There are three measures of center (averages)—the mode, the median, and the mean. The *mode* is the value that occurs most frequently in a set of data. It can easily be skewed by data bunched on the low or high end.

The *median* is the middle value in an ordered set of data. If the set is odd, the median is the middle number. If the set is even, the median is the mean of the two middle numbers. Half of the numbers are at or above the median and half below.

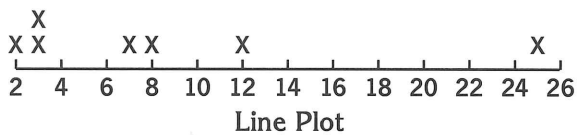
The National Council of Teachers of Mathematics (NCTM) emphasizes the median for the middle elementary grades because it is easier to understand, easier to compute, and, in most cases, not affected by large or small values outside the bulk of the data.

The arithmetic *mean* is the average computed by adding all of the values (elements) in the set and dividing by the number of values in the set. In this activity, the concept of mean is introduced by "robbing the rich to give to the poor." Letters from longer words are given to shorter words until all the words in the set are as even as possible. It then progresses to the calculation.

Spread

Another key aspect of data is its *spread* or distribution. For small amounts of data, say less than 25, a line plot is a quick way to visually show the spread. A line plot, also called a frequency graph, is simply a number line with an *x* marked for each value in the data set. It reveals the largest and smallest values (range) and where there are clusters and gaps.

Example: 2, 3, 3, 7, 8, 12, 25



Line Plot

The mode is 3. The median is 7. The mean is 8.6.

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This activity is more than an exercise in identifying the median (or mean). Students need to understand what the median tells them about the data and how the median relates to the spread. Because this understanding rarely comes from one experience and because NCTM stresses the importance of comparing related data sets, three sets of data are provided.

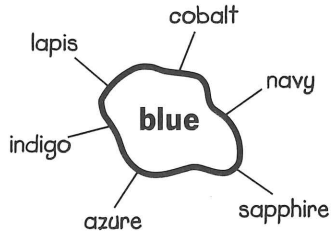
Management

1. This is a three-part investigation. In *Part One,* the blue, yellow, and red word webs are developed, forming the data sets used to explore line plots and the median. For those who are ready, *Part Two* introduces a concrete way to determine the mean while *Part Three* leads to calculating the mean.
2. Consider doing *Part One* the first day and *Parts Two* and *Three,* if appropriate for your class, the next day.
3. Organize students into pairs.

Procedure

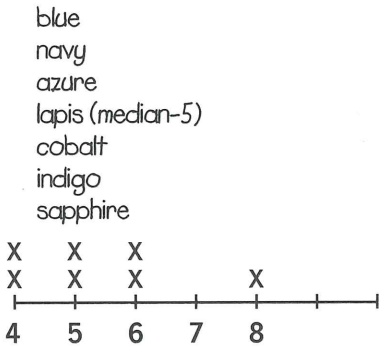
Part One

1. Encourage student pairs to brainstorm words for blue. Conduct a sharing session, writing down their suggestions.
2. Explain that students will be working with synonyms for blue, yellow, and red. Some of their brainstormed words may be included, and new ones can be added to the class list.
3. Give student pairs the color web page and instruct them to follow the directions.



Sample web

4. After confirming the color groupings, tell students they will be using these word sets to learn more about interpreting data.
5. Distribute the median/line plot page.
6. Have students order each color word group and identify the median. For those who need a more concrete process, have them write the seven words on graph paper (one letter per box), cut out the word strips, order the strips, and record.
7. Model how to construct a line plot and direct students to complete the three line plots on the page.



8. For each word group, ask students to describe how the word lengths are spread (including range) and where the median falls.

Part Two

1. Tell students they will now learn about another kind of center or average.
2. Give students the mean page and the graph paper.
3. Have students follow the directions on the page, focusing on one color word group at a time.
4. Ask students to describe the mean for each group. This is not a calculated mean, so students will talk in terms of whole numbers such as "It's almost halfway between five and six" or "It's a little more than six."
5. For each color word group, instruct students to compare the mean to the median and to the line plot in *Part One.*

Part Three

1. Introduce another medium for determining the mean by distributing lima beans or blocks to pairs of students.
2. Choose a group of words and have students count out one bean for each letter, pool the beans, and divide them into fair shares (seven groups for seven words).
3. Repeat, as needed, for other word groups.
4. Explain that, many times, the mean is somewhere between two whole numbers. Ask if there is another way to determine the mean more precisely. [Add the numbers and divide by the number of elements in the original set.]
5. Instruct students to calculate the mean for each group of words. Round to the nearest tenth.

Discussion

Part One

1. Describe the spread for the blue words. [The range is 4 to 8. Most are 4s, 5s, and 6s; there is a gap before the 8.] Where does the median fall on the line plot? [The median is 5, on the lower end of the line plot.]

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2. Describe the spread for the yellow words. [The range is 5 to 11. Most words are 5s and 6s; then there is a big gap and one 11.] Where does the median fall on the line plot? [The median is 6, in the area where most of the *x*s are clustered.]
3. Describe the spread for the red words. [The range is 3 to 8. The words are quite evenly spread.] Where does the median fall on the line plot? [The median, 6, really looks like it is in the middle.]
4. How does the spread on the three line plots compare? [They look different. The ranges vary. The yellow words are bunched up at 5 and 6 with a large gap while the red words are almost even all the way across. The blue words have a little bunching and a little gap.]
5. Going further: Make a line plot combining the words from all three groups. What is the range? [3 to 11] How can you find the median just by looking at the line plot? [For twenty-one pieces of data, the 11th one would be in the middle. Since the line plot is in order from lowest number to highest number, start counting at the low end until you reach the 11th *x*.] What is the median? [6, just barely]

Part Two

1. How would you describe the mean for the blue words? [about halfway between 5 and 6] Mark its approximate position on the line plot. How does it compare to the median? [The mean is higher than the median (5).]
2. Describe the mean for the yellow words. [more than 6] Mark its approximate position. How does it compare to the median? [The mean is slightly more than the median (6).]
3. Describe the mean for the red words. [about halfway between 5 and 6] Mark its approximate position. How does it compare to the median? [The mean is lower than the median (6).]
4. Is each mean represented by a value on the line plot? Explain. [No, each one happens to be between the whole numbers on the line.]
5. Can you think of another way to determine the mean length of these words? [Add the total number of letters in the set and divide by the number of words.]

Part Three

1. How can we determine the mean more precisely? [Add the number of letters and divide by the number of words in the set.]
2. Challenge: Calculate the mean of all 21 words or a word set suggested in the *Extension*.

Extension/Assessment

To further develop or to assess data analysis skills, have students construct line plots and determine the median and mean for an odd number of:

- words for green or another color
- names of car companies
- first names of classmates
- NFL or NBA team names

Curriculum Correlation

Literacy

1. To promote an expanding vocabulary, keep color lists posted around the room and add new words as students discover them. Resources for new words include clothing catalogs, a crayon website, and paint chips. Encourage the use of a variety of color words in journals, stories, and other writing.
2. Put the blue, yellow, and red color words together in a sack. Have students draw four or five words and create a story using them.

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(CRICKETS, cont. from page 5.)

4. Have students turn to the page with the blank cricket diagram in their journals so that they can identify and label the body parts that help the crickets sense things as you share the information with the class.
5. Lead the class in a discussion comparing the body parts that we use to sense with those used by crickets. Have them record this information in their journals on the page provided.

Discussion

1. How do crickets use their sense organs?
2. Where are they located?
3. How do the crickets know where food is located?
4. Were our predictions about crickets use their senses to investigate the world correct?

Extension

Research how crickets are viewed in other cultures, such as in China.

Curriculum Correlation

Aliki. *My Five Senses.* Harper Trophy. New York. 1990.

Carle, Eric. *A Very Quiet Cricket.* Putnam Publishing. Itasca, IL. 1997.

Caudill, Rebecca. *A Pocketful of Cricket.* Henry Holt. New York. 1975.

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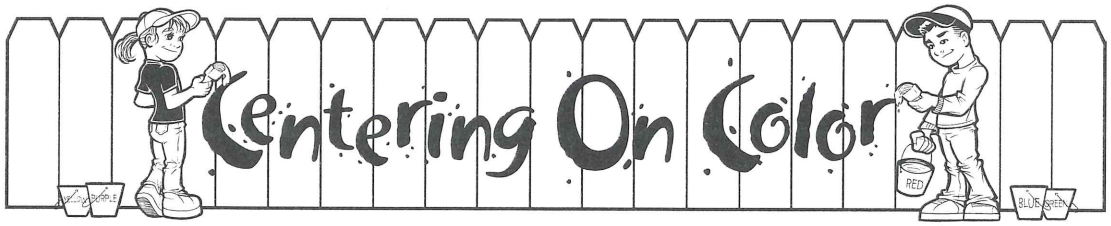

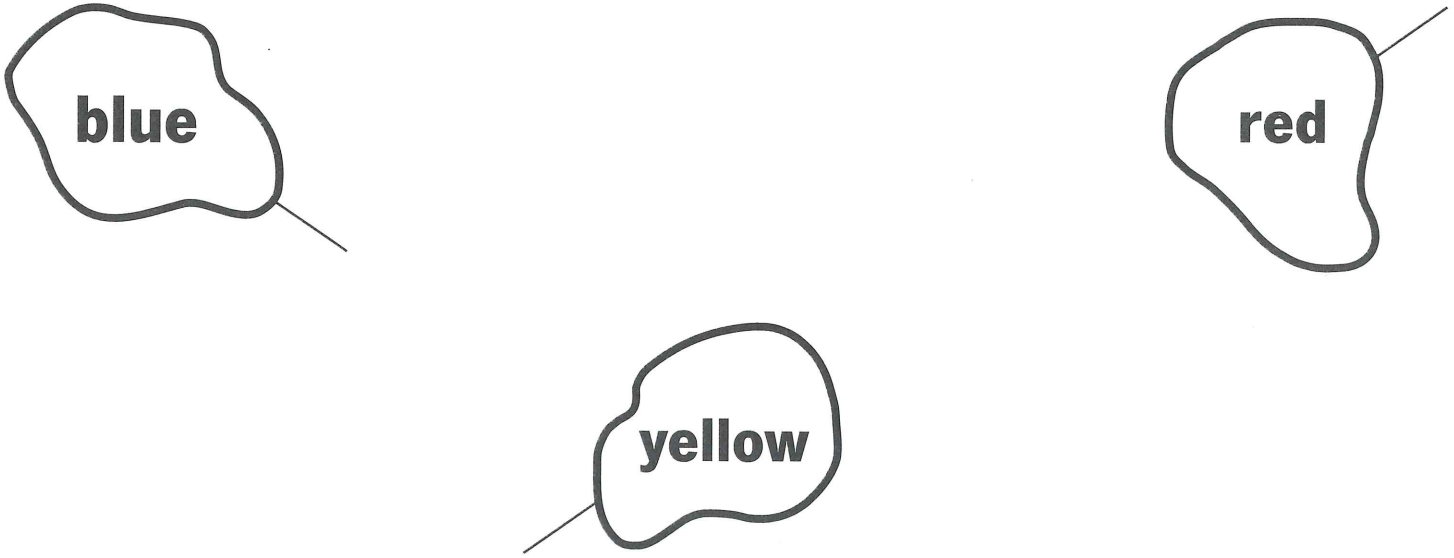

Build the blue, yellow, and red color webs with the synonyms below. Use what you know and a dictionary.

crimson	lemon	canary	ruby	cobalt	burgundy
navy	topaz	indigo	scarlet	buttercream	lapis
cherry	sapphire	brick	blond	azure	banana

For each word group:

- Write the seven words in order from shortest to longest.
- Record the number of letters in the middle word. →
- Make a line plot of word lengths.

What is the typical word length?

This is the **median**, the center of an ordered list. It is one kind of average, one way of describing where the data are centered.

1st Color

2nd Color

3rd Color

For each color group, describe how the word lengths are spread.
Where is the median on each line plot?

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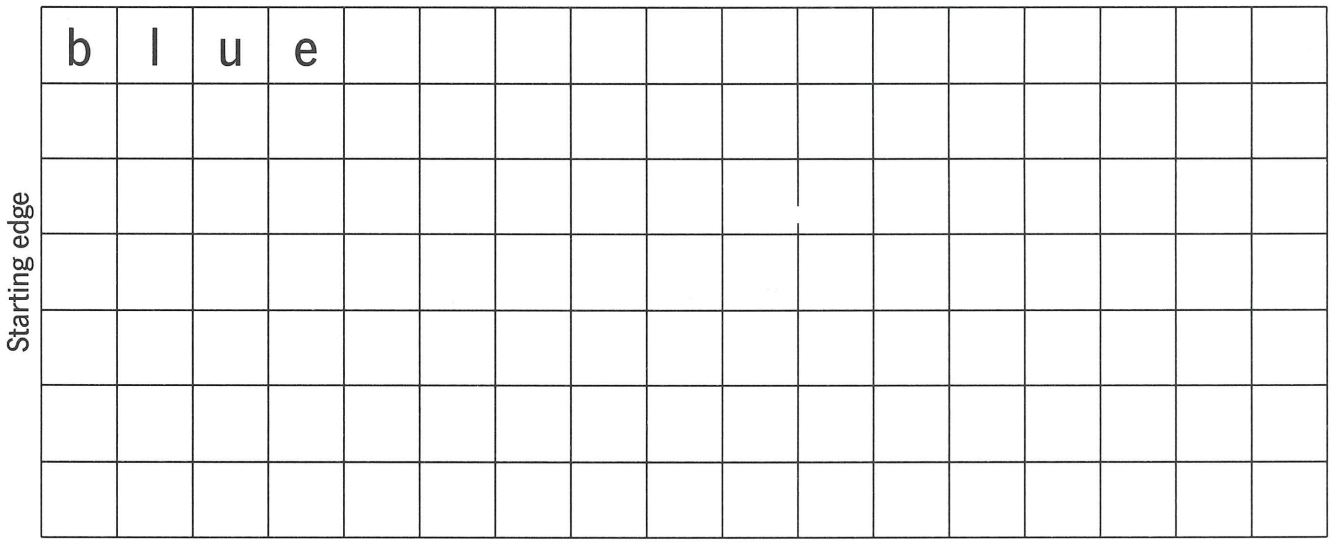
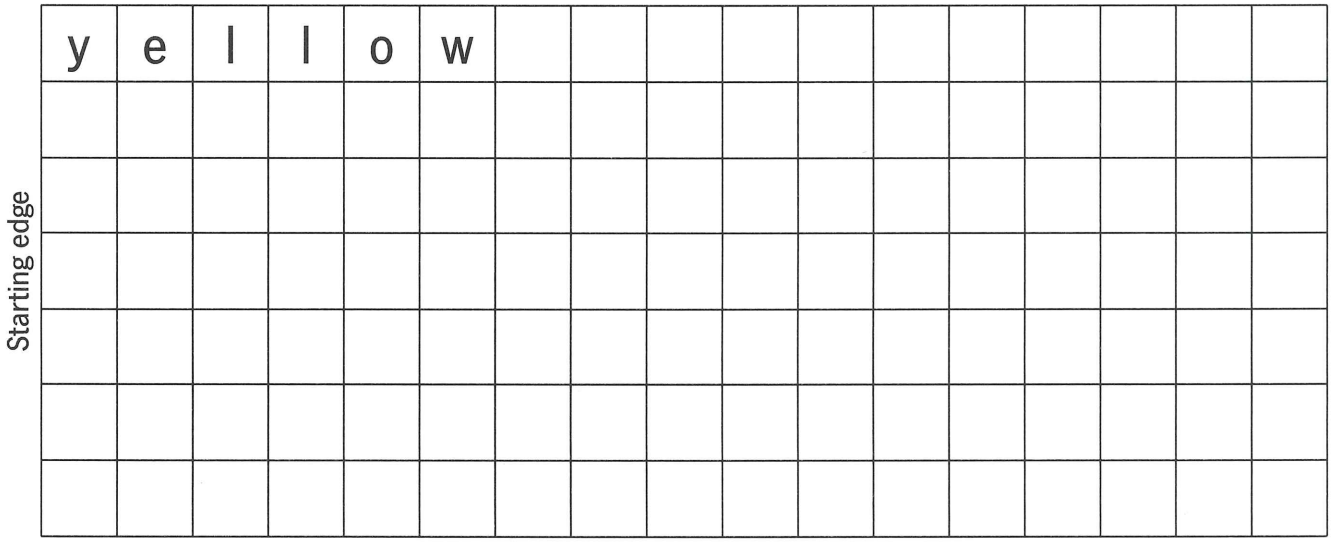
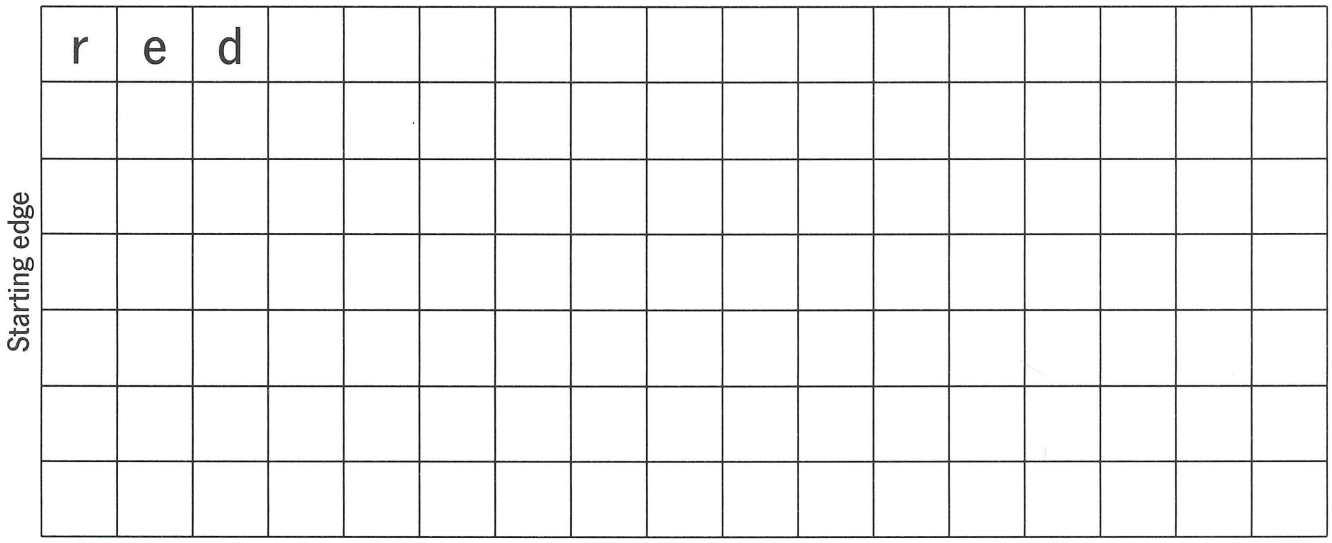
Centering On Color







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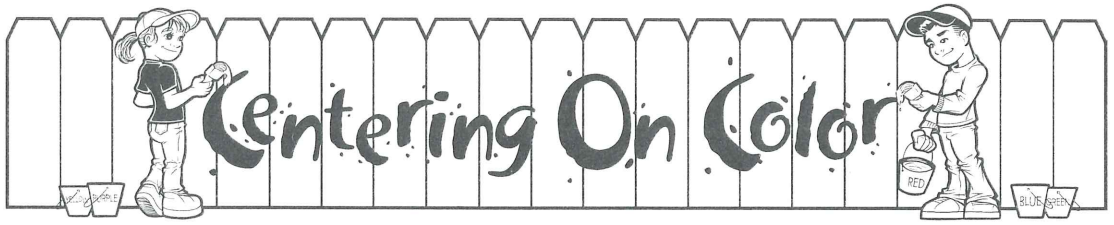

For each word group:

What is the typical word length?

- Write the seven words in a grid, one letter per box.
- Cut around the outer edge of the whole group of words. Glue or tape down the starting edge only.
- Exchange just enough letters, by cutting, so that each word is the same length or only one letter different. Glue or tape.
- Count the number of letters each word has now. This is the **mean**, another kind of average or measure of center.

1st Color

2nd Color

3rd Color

For each color group, describe the mean.

How does the mean compare to the median? How does the mean relate to the line plot?

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PRIMARILY PROBLEM SOLVING

NUMBO

by Michelle Pauls

"BINGO!!" As the shout goes out, murmurs of disappointment can be heard around the room. "I was so close!" "I only needed one more space!" "If she had just called B4 I would have won!" With sighs of resignation, and high hopes for another round, chips are cleared from the boards in preparation for the next game. No doubt we have all witnessed or been a part of such a scene at some point in our lives. Bingo remains a popular game with adults and children alike, and has the advantage of being easily adaptable to many situations.

NUMBO is our own version of Bingo with a slight twist that actually introduces an element of strategy into the game. The spaces on a NUMBO card are filled with multiple representations of the numbers from one to six. Each number is represented in four different ways: with the numeral (1), with the written word (one), with dots (•), and with tallies (|). Multiple representations of each number mean that in any one column a given number could appear up to four times. This is where the strategy comes into play. If a student has two fives in his "B" column, and "B5" is called, he will have to determine which of those two spaces would be the most advantageous to select. The goal of the game is for students to become comfortable with each of the various representations of the same number and to provide them with an opportunity for developing simple strategies.

To play, each student will need a copy of the game board, one set of number cards, and about 20 marking chips (math chips, beans, coins, etc.). If you do not wish to make a copy for every student, they can play in pairs or small groups. It is recommended that you copy both the game board and the number cards onto card stock for durability. The number cards should be cut out for students ahead of time. Each student will be responsible for setting up his or her own game board by randomly placing the number cards in the empty spaces on the NUMBO grid. This allows students to create a new game board whenever desired. You may choose to have students tape or glue their cards in place so that they don't move around; however, this limits the flexibility of the game.

The game is played like Bingo, with a caller reading out letter/number combinations, and the players covering one space on their boards each turn, if possible. When a player gets five markers in a row horizontally, vertically, or diagonally, he/she calls out "NUMBO!" and the game is over. The star in the center of the board is a free

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space and may be used by all players. The letter/number combination cards are provided for you to copy and cut out. These can be placed in a hat or basket to be drawn out one at a time. Because any number could appear as many as four times in the same column, two copies of each letter/number combination are given. Even so, it may be necessary to go through the cards more than once before a winner is found.

Variations & other games

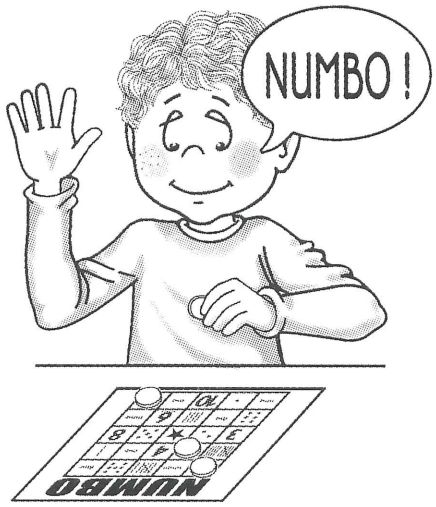
There are many variations of NUMBO which can be played using the cards and the grid provided.

- *Blackout*: the entire NUMBO grid must be covered.
- *Four corners*: each of the four corners must be covered.
- *Blockout*: a block of spaces of specified dimensions (e.g., 2 x 2, 2 x 3, 3 x 3, 2 x 4, etc.) must be covered. The block may be anywhere in the grid.

The number cards have other potential uses as well. Students can play memory by placing the cards face down on their desks and turning over two cards each turn. If the two cards are both a representation of the same number, they are removed from the game and that student gets to go again until he/she does not find a match. When all of the cards have been paired up, the game is over and the student with the most matches wins.

Number cards for the digits seven, eight, nine, and ten are included as another extension. As students grow comfortable with the digits one through six, the higher numbers can be substituted. They can also be used to make the memory game more challenging by adding more cards.

I hope you and your students are able to use NUMBO as a fun way to explore multiple representations of numbers. As always, I welcome your feedback on this, or any other *Primarily Problem Solving* activity. You can write to me at AIMS or email me: meyoungs@fresno.edu.



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NUMBO

Copy and cut out one set of number cards for each student or pair of students. Use card stock for greater durability.

1	•	|	one
2	• •	||	two
3	• • •	|||	three
4	• • • •	||||	four
5	• • • • •	𝍸	five
6	• • • • • •	𝍸|	six

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NUMBO

Extra number cards

7			seven
8			eight
9			nine
10			ten

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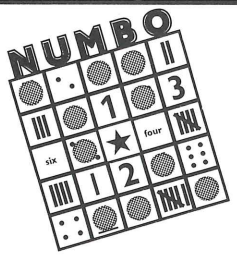
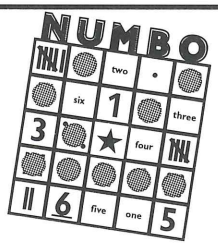
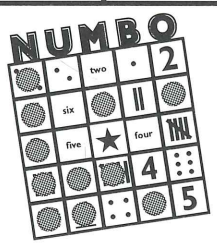
NUMBO







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Letter/Number Combination Cards

N one	N two	N three	N three
U one	U two	U three	U three
M one	M two	M three	M three
B one	B two	B three	B three
O one	O two	O three	O three
N four	N five	N six	N six
U four	U five	U six	U six
M four	M five	M six	M six
B four	B five	B six	B six
O four	O five	O six	O six
N one	N two	N four	N five
U one	U two	U four	U five
M one	M two	M four	M five
B one	B two	B four	B five
O one	O two	O four	O five

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WINGING IT!

by Sheldon Erickson

Topic
Human body

Key Questions
How are the muscles and skeleton held together?
How to do the muscles and bones work together to provide motion?

Learning Goals
Students will:
1. learn how muscles work together with the skeleton to provide motion, and
2. learn how the muscle and skeletal system are held together.

Guiding Documents
Project 2061 Benchmark
- *Like other animals, human beings have body systems for obtaining and providing energy, defense, reproduction, and the coordination of body functions.*

NRC Standard
- *The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control, and coordination, and for protection from disease. These systems interact with one another.*

Science
Life Science
human body
muscle system
skeletal system

Integrated Processes
Observing
Comparing and contrasting
Recording
Inferring

Materials
Chicken wings
Styrofoam meat trays
Butcher paper or newspaper
Cutting instrument (scalpel, craft knife, kitchen knife, one-bladed razor blade, large straight pins)
Colored pencils
Plastic or latex gloves, optional

Background Information
A chicken wing is anatomically analogous to the human arm. Although the major bones, joints, and muscle groups differ in size, their basic shape, location and motions are the same.

As students carefully cut and pull back the skin on the wing, it reveals the muscles and skin formation. On the underside of the skin they should be able to see a small underlying layer of fat and the thin connective tissue between the skin and muscles. As they hold the skin up against a back light, they will be able to see capillary networks in the skin.

With the skin peeled back, students should be able to identify distinct muscle groups and can match them to those in their arms. The biceps on the inside of the upper wing, or front of the arm, and the triceps along the back of the upper wing and arm are the easiest to identify. The students can feel the thin sheathing that connects but separates the bundles of muscles. As students flex the wing by pushing and pulling the tip of the wing while holding the shoulder, they will see the opposing muscles in opposite conditions. As the biceps contract, the triceps are stretched.

As students are asked to carefully look at the elbow and wrist they will observe the white tendons that attach the muscles to the bones. They are easily found on the outsides and back of the elbow and wrist joints.

Working the muscles near the tendons with their fingers or a blunt object, like the rounded point of a worn pencil, students can begin to separate the muscle groups from each other.

As the muscle groups are separated, students can begin to observe how the contraction of each muscle affects the motion of the wing. Pulling on the biceps pulls the lower wing up. The counter motion of pulling on the triceps extends the lower wing. Similar motion can be made to the wing tip by pulling on the muscle on the top of the lower arm and then pulling on the muscles on the sides of lower wing. As students pull on the muscles they will see the white iridescent tendons move. They will also be able to see the space formed in joints or connective tissue that keep the tendons in the correct positions while allowing them to move. Students will be making these interesting observations as they entertain themselves making the chicken wing punch and wave.

When students carefully cut away the bulk of the muscles (meat) just above each tendon, they will expose the joints. When the muscles have been separated from the elbow joint, students can observe its construction. As they grab the upper and lower wing bones and pull them apart with a firm tension, they will separate the joint slightly and will see the white taunt ligaments. Carefully cutting or snipping these ligaments will allow the joint to be easily separated. As

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students pull the joint apart they expose the smooth white cartilage on the inside of the joint. As they feel it, they will recognize how the cartilage provides smooth, low-friction motion, while the ligaments keep the joint in tight alignment. By scraping the cartilage and the bones with a blunt instrument, they will recognize why the joints are more susceptible to injury then the bones.

Management

1. Chicken wings are easily purchased at a grocery store. One wing per group of four students works well. Chicken legs can be substituted for wings. Chicken legs are not as anatomically similar to human legs as wings are to arms, and they are more expensive. However, the skin is pulled back more easily on legs, and if working with younger students, legs may provide a better experience.
2. Putting sharp instruments into the hands of children can be dangerous. Before beginning the activity make sure that students are aware of the dangers and are coached in ways to avoid injury. Stress that their cutting motions move the knives down into tables or cutting boards and not up into people. Some teachers have found success in having students separate the skin and muscle groups by having one student pull the skin away from the meat while a second students scrapes at the connective tissue with the point of a straight pin.
3. To reduce the risk of exposure to salmonella, the work area should be covered with butcher paper or newspaper. After the investigation, the area should be sanitized by washing with a bleach water solution or another antiseptic.
4. If the danger with knives is too great for the class, the teacher may choose to dissect chicken wings to different levels and then just allow students to move from station to station making observations.
5. It is best to allow enough time in one day to get the investigation done unless you have adequate refrigeration to preserve the raw meat.
6. Most students are willing to work with a chicken wing, as it is a very familiar object, although for most of them it is cooked before they touch it. Some students do not want to work with a raw chicken wing. The teacher may choose to provide disposable gloves for students to wear, although they often make it harder for the students to work with the chicken wing. **Make sure students wash their hands thoroughly with soap and hot water after doing the investigation.**

Procedure

1. Distribute a dissecting tray (styrofoam meat tray) to each group with a chicken wing and the student recording pages. Have the students record the external differences and similarities between their arms and the chicken wing.
2. Have students identify and record the analogous parts of the wing and arm and color their locations the same.
3. After clearly discussing safety rules and practices, distribute the cutting instruments and gloves (optional). Have students cut and pull back the skin from the shoulder to the lower wing.
4. Instruct students to observe the interior of the skin and identify and record the underlayer of fat, connective tissue, and capillaries.
5. While pulling and pushing on the shoulder and wingtip, have students observe how muscles contract and extend and identify and label by color the chicken's biceps and triceps.
6. By carefully working the upper wing muscles with a finger or blunt instrument, have the students separate the muscles into groups of biceps and triceps. When the muscles are separated they can grasp each and alternately pull (contract) on each to make the lower wing punch. (Students may choose to follow a similar procedure on the lower wing to make it wave.)
7. As students make the wing punch by contracting opposing muscles, have them observe how the muscles connect to the bone. They should be able to identify and label by color the tendons as each moves through openings in the muscles or indentations around the joints.
8. After identifying the tendons, have the students cut them from the muscles around the elbow. As they remove the muscles, the elbow will be exposed.
9. As the students pull with a steady tension on the exposed elbow, a gap should open allowing them to see the taunt ligaments that hold the elbow together. After they identify the ligaments, have students cut them to separate the joint.
10. Students should touch the cartilage, and scrape it and the bone with a blunt object to observe the differences in texture and strength. Students should also notice where the ligaments and tendons attach to the bones, recording all their observations and labeling with color.
11. After cleaning up the investigation, have students summarize what they have learned about the muscles, and skeletal systems and how they could apply that knowledge to themselves.

Discussion

1. Externally, how are a chicken wing and your arm similar and different?
2. Why do you need two opposing muscles for every movement of your skeleton? [contract and extend, pull back and pull forth, muscles can't push]
3. Why does each end of a muscle need to attach to a different bone? [Muscles move a bone around a joint. If both ends of one muscle were attached to the same bone, it could only squish the bone.]
4. How are tendons and ligaments different? [tendons hold muscles to bones, and ligaments hold bones to bones]
5. Why are joints more likely to be injured than bones?

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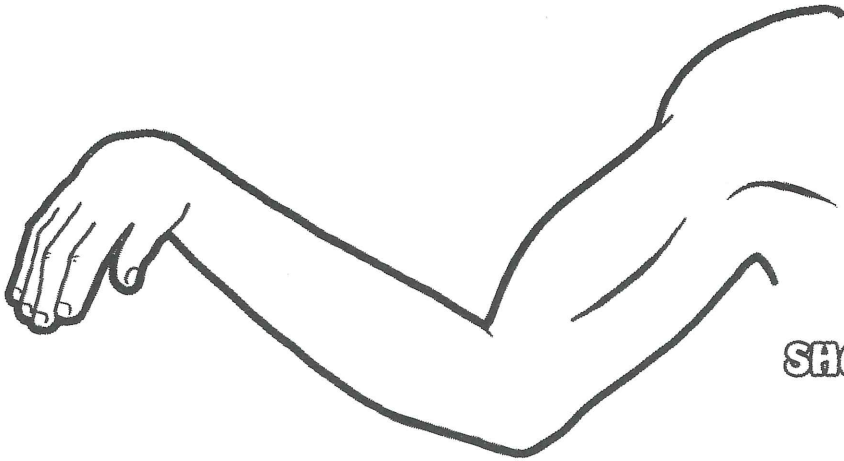
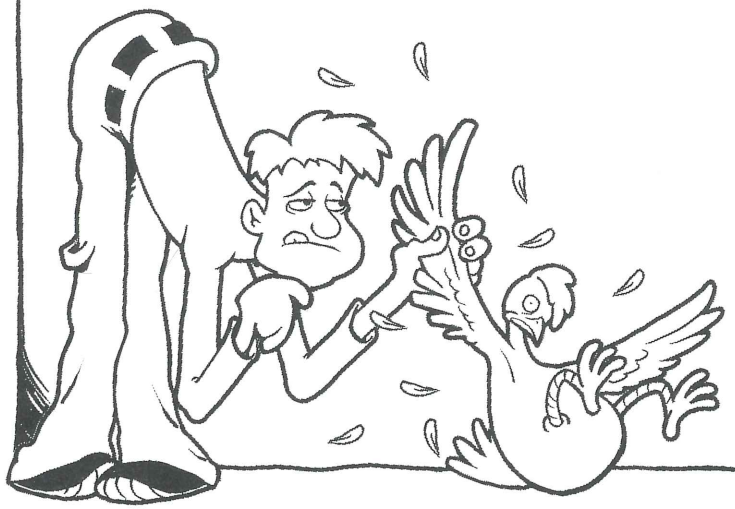
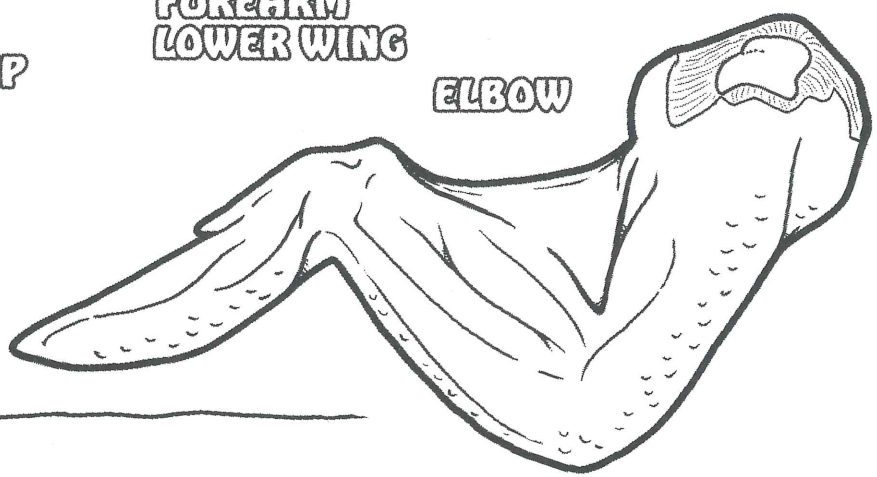
WINGING IT!

How is your arm like a chicken wing?





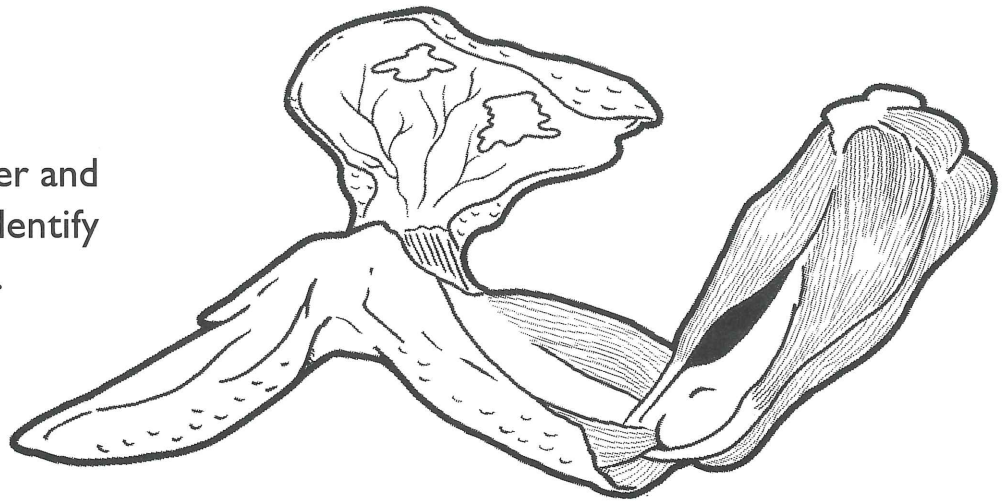


Compare and contrast wings and arms.

WINGING IT!

1. Carefully cut a slit down the wing from the shoulder to the lower wing. Try to cut from the inside of the skin to the outside so you do not cut up the muscles. Pull on the skin by the shoulder and pull it back to the lower wing. You might have to cut some of the connective tissue to help the skin separate. Identify the underlayer of fat, the capillaries, and connective tissue by coloring the label and part the same color.

2. Grab the wing by the wing tip and shoulder and pull and push it. Watch the muscles and identify when muscles are stretched and squished. Identify the biceps and triceps by coloring the label and muscle the same color.



3. Carefully work your fingertip or a worn pencil tip between the muscles until they separate into the muscle groups. Pull on each group to see how the muscle makes the wing move. Notice how and where the muscle attaches to the bone. Use several muscle groups and see if you can get the wing to punch or wave. Identify the tendons and bones by coloring the label and the part the same color.

UNDERLAYER FAT
CAPILLARIES
CONNECTIVE TISSUE
BICEP
TRICEP
TENDONS
BONES

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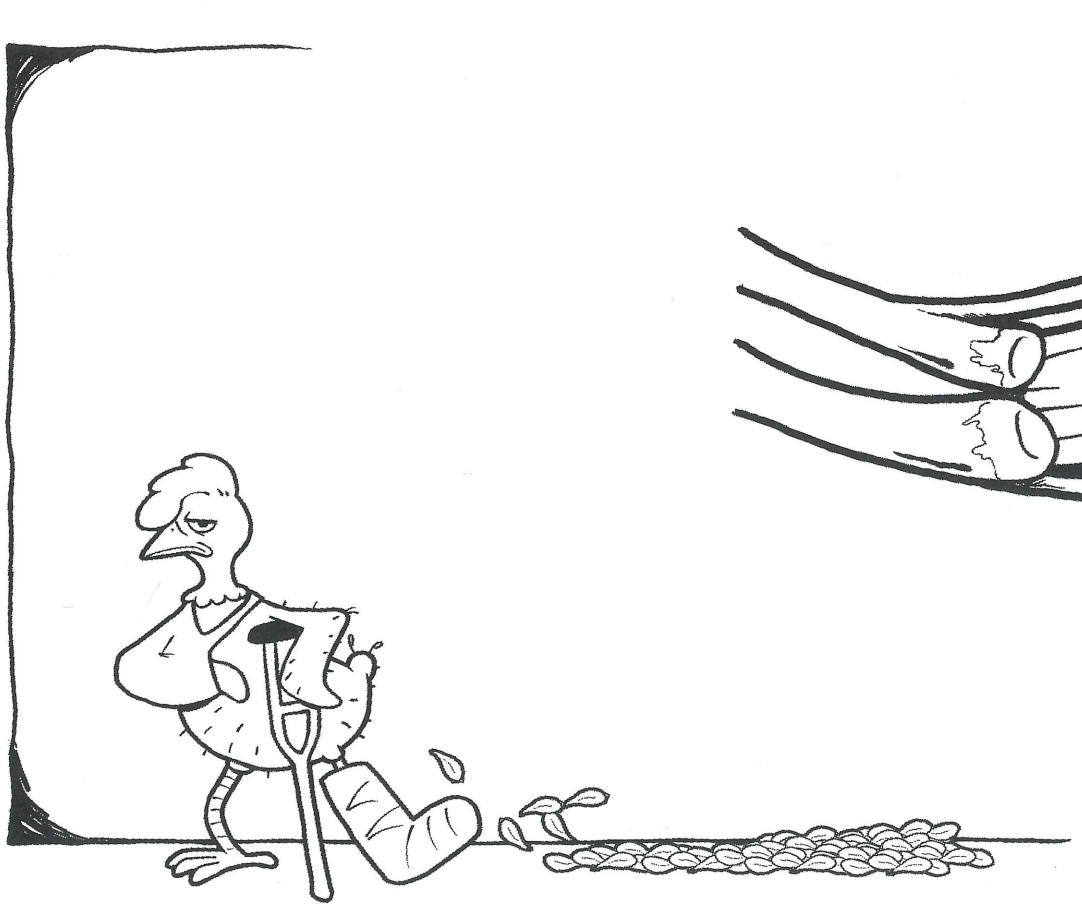
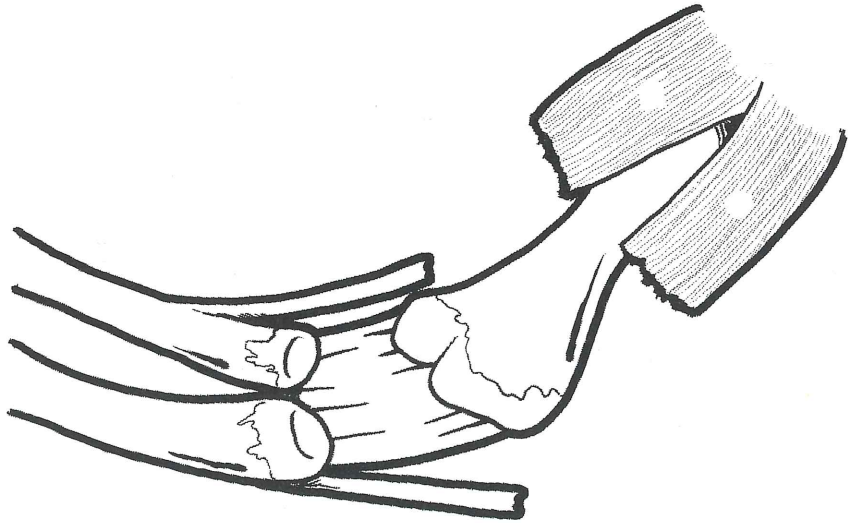
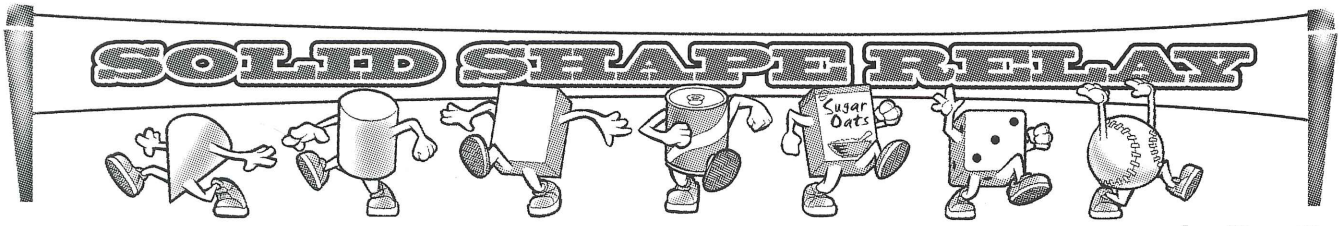
WINGING IT!

4. Cut all the tendons around the elbow and pull away the muscles. Pull slowly on the bones to make a small gap in the elbow. You should be able to see the ligaments inside the joint. Cut the ligaments to separate the joint. Look and see how and where the ligaments and tendons attach. Feel the cartilage in the joint where the bones touch. Scrap the cartilage and bone to see how different they are. Identify all the labeled parts by coloring them the same color.





LIGAMENTS
CARTILAGE
TENDONS
BONES
MUSCLES



by Kay Kent

Topic:
Geometry/solids

Key Question
What attributes did you use to sort your solids?

Focus
Students will play a game during which they will sort various solids into like groups.

Guiding Documents
Project 2061 Benchmarks
- *Circles, squares, triangles, and other shapes can be found in things in nature and in things that people build.*
- *Shapes such as circles, squares, and triangles can be used to describe many things that can be seen.*

*NCTM Standards 2000**
- *Recognize, name, build, draw, compare, and sort two- and three-dimensional shapes*
- *Describe attributes and parts of two- and three-dimensional shapes*

Math
Geometry
3-D shapes
Sorting

Integrated Processes
Observing
Comparing and contrasting
Identifying
Communicating

Materials
AIMS Geo-Solids
Various real-world examples of solids
(see *Management 3)*
Paper grocery bags or small boxes for sorting
Labels for the bags or boxes

Background Information
Young children need repeated experiences in order to develop and extend their understandings of geometry. Using geometric solids from the real world, as well as models of geometric solids, provides opportunities for students explore the characteristics and properties of both. Students are fascinated by the attributes of, and names for shapes. As they sort and sort again, they will begin to notice similarities and differences in the various shapes.

This activity is designed to engage students in a physical game while applying the sorting of solids by similar attributes. Physical activity is important for students as they expend their energy and important for learning because physical activity increases the potential for remembering new skills. The students can play the game over and over as a review, and decide on other ways to sort the objects for the game.

Management
1. This activity is designed to give students additional practice identifying and sorting solid shapes. The assumption is that students have had repeated experiences sorting and identifying solids before playing the game.
2. Students should be familiar with relay-type games in which they run to a given area and return to touch the next member of the team.
3. A large and varied collection of geometric solid shapes should be gathered prior to the activity. Both the AIMS Geo-Solids and real-world examples of those solids should be used. Try to gather a variety of sizes of the same shape. You will need at least one object for every person in the class.
4. Use the page provided to label the boxes, or bags, that will be used as sorting vessels. The first few times the game is played, use the common names for the solids. (Cone, sphere, cube, rectangular prism, etc.) When students are ready for a change in the rules, they may suggest other attributes by which the shapes can be sorted. (Straight sides, corners, straight lines, points, etc.) Use the blank spaces provided to make your own labels for this portion of the activity.

Procedure
1. Divide the students into two to four teams. There should be at least four students per team.
2. Review the names of the solids students will be sorting and have students share the characteristics of these solids. [spheres are round, cubes are square all the way around, cones have a pointed end and an end that's a circle, etc.]
3. Show the teams the collections of geometric solids, and the areas where they will sort the

(See RELAY, page 38.)

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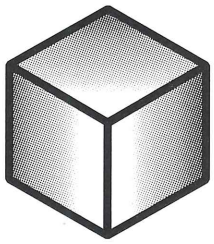
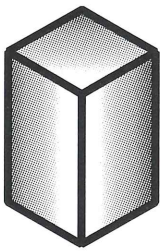
 **Cube**	
Rectangular Prism 	
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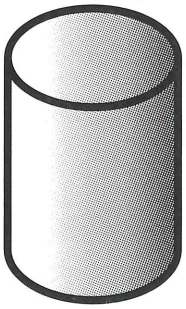
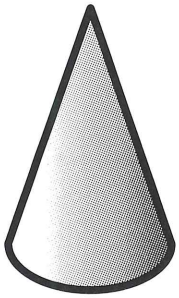
Cylinder 	
 **Cone**	

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Introducing a NEW Core, Hands-On Science Curriculum for Grades 4-5...

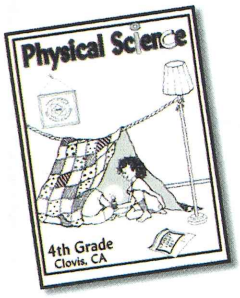
from AIMS, your Leading Source of Educator-Developed Math & Science Resources

After more than 20 years of successful leadership in supplementary science and mathematics publishing and professional development, AIMS has now launched an innovative new core curriculum in science for grades four and five.

Field Tested & Developed to Extend the AIMS Approach to Full-Year Science Programs

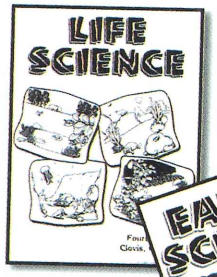
Our new core curriculum program will be customized to meet your specific state and district standards and is comprised of hands-on investigations in physical, earth, and life sciences. The program has been extensively field tested in schools and is now ready for broader adoption and customization.

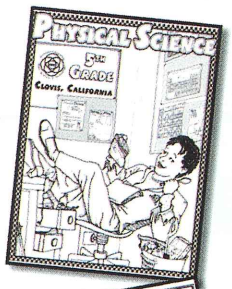
Each module includes math, reading in key content areas, hands-on investigations, assessments, and school-to-home connections.



Grade 4

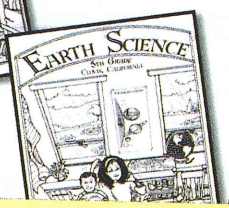
Physical Science
Magnetism & Electricity
Life Science
Food Chains & Food Webs
Earth Science
Rocks & Minerals
Investigation & Experimentation
Using the Scientific Method to Collect & Analyze Data

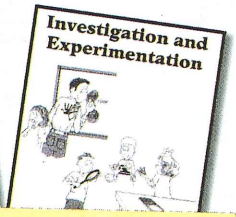




Grade 5

Physical Science
Chemistry
Life Science
Transport Systems in Plants & Animals
Earth Science
The Water Cycle, Weather, The Solar System
Investigation & Experimentation
Using the Scientific Method to Collect & Analyze Data





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Literature Links

by Myrna Mitchell

Thomas Edison: The Great American Inventor

Thomas Edison: The Great American Inventor by Louise Egan (Barrons Solution Series. New York. 1987) is part of the Solutions Series which are biographies written for students ages 9-12. The biographies examine the lives and achievements of famous inventors in narrative form.

This particular biography covers the life of Thomas Edison from boyhood through his 60 plus years. It reveals events that influenced Edison's life and led to his many scientific contributions. *Thomas Edison: The Great American Inventor* allows students to see Edison the boy, the man, and the famous inventor.

While reading this book, students see a rags to riches story of a man who had failures as well as successes in his life. Students will see how a young Tom overcomes scarlet fever, the loss of his hearing, and even the opportunity for a formal education and yet keeps a positive attitude.

Thomas Edison: The Great American Inventor by Louise Egan provides an opportunity for teachers to integrate literature and science. While reading the biography on Edison, a class study of electricity would be very appropriate. Students could learn about the invention of the first light while using light bulbs to demonstrate parallel and series circuits, etc.

This book also provides an extensive glossary for students to use as a quick reference as they read for understanding. To extend the experience, a section with topics for discussion and a reference book list are also provided for teachers.

Suggested Language Activities

- Have students research the impact of Edison's inventions on society.
- Have students research their own communities to see how changes in technology and industry have altered the landscape.

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- Ask students to choose a famous inventor, write a report, and develop a visual on the person to share with the class in an oral presentation.
- Tell students to pick one common invention (electricity, the telephone, television, the paper clip, glue, the camera, the pencil, etc.) and research the history behind the invention. Ask the students to include what the world would be like if the item had never been invented.
- Have the students produce an inventor newspaper. This can include descriptions of new inventions and public opinion concerning the unveiling of things such as the light bulb.
- Have students pick an invention and work on a campaign for funding in order to further develop that invention. Discuss why it's necessary, give its benefits, etc.
- Research the patent process.
- Research to see what new technology is currently being invented. Have your students research the new technology, and then debate the pros and cons of this breakthrough.
- Discuss what constitutes success in inventing. For example, Thomas Edison was not "successful" in his rubber experiments, but the advancements he made in the field helped lead to a new generation of rubber and plastics.
- Discuss perseverance. Ask the students to write essays about a time in their lives when they had to persevere. Have them describe how the experience affected them and how it affected others' views of them. Allow them to share with the class if they would like.
- Ask your students about their favorite sport or favorite game. Ask them to find out who invented it and a little bit about the history of the game.
- Discuss the problems of being an inventor. [People might think you are crazy, no steady income, invent something that hurts people such as bombs, etc.]
- Have your students trace their family histories to see if they find any inventors in their family trees.

Suggested Math, Science, and Social Studies Activities

- "Short Cuts" (*Electrical Connections*)
- "Circuit Quiz Boards" (*Electrical Connections*)
- "Static Extensions" (*Electrical Connections*)
- "Lightning" (*Electrical Connections*)
- "Nikola Tesla" (*AIMS®*, Vol. VIII, No. 10)
- "Electric Circuits" (*Electrical Connections*)
- "Put Your Name in Lights" (*Electrical Connections*)
- "Static Strokes" (*Electrical Connections*)
- "Light the Light" (*AIMS®*, Vol. X, No. 4)
- "Conductors of Electricity" (*AIMS Newsletter*, Vol. III, No. 4)
- "When I Was Ten" (*Electrical Connections*)
- "Make a Dimmer Switch" (*Electrical Connections*)
- "Meter Readers" (*Popping with Power*)
- "Path Finders" (*Electrical Connections*)
- "Can-Sealed Circuits" (*AIMS®*, Vol. IX, No. 3)
- "Sparky's Light Kit" (*Electrical Connections*)
- "Electricity Time Line" (*Electrical Connections*)
- "Circuit Breaker" (*Electrical Connections*)
- "Static Magic" (*Popping with Power*)
- "Conductor or Insulator?" (*Electrical Connections*)
- "Lighten Up" (*Popping with Power*)

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- "Benjamin Franklin, the Scientist" (*AIMS Newsletter*, Vol. IV, No. 10)
- "What's the Static?" (*AIMS®*, Vol. XIII, No. 7)
- "Long Distance Runners" (*AIMS®*, Vol. X, No. 6)
- "William Gilbert, the Father of Magnetism" (*AIMS Newsletter*, Vol. IV, No. 9)
- "Different Strokes" (*Electrical Connections)*
- "All Charged Up" (*AIMS®*, Vol. XII, No. 2)
- "Make a Switch" (*Electrical Connections)*
- Divide your class into teams and give each group the assignment of creating a new invention. Hold an invention convention where students can display inventions that they have created.
- Have your class learn about accidental inventors—individuals who discovered things by accident.

Following this article you will find an activity that was written specifically to be used with this book.

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Fiddling with Filaments

by Myrna Mitchell

Topic
Electricity

Key Question
What can we learn about the incandescent light bulb by studying a model light bulb?

Learning Goals
The students will:
1. construct a model light bulb, and
2. test a variety of materials as filaments to see which materials will glow.

Guiding Documents
Project 2061 Benchmarks
- *Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments. Investigations can focus on physical, biological, and social questions.*
- *Things that give off light often also give off heat. Heat is produced by mechanical and electrical machines, and any time one thing rubs against something else.*
- *Seeing how a model works after changes are made to it may suggest how the real thing would work if the same were done to it.*

NRC Standards
- *Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.*
- *Electricity in circuits can produce light, heat, sound, and magnetic effects. Electrical circuits require a complete loop through which an electrical current can pass.*

*NCTM Standards 2000**
- *Understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute*
- *Understand the need for measuring with standard units and become familiar with standard units in the customary and metric systems*

Math
Measurement
linear

Science
Physical science
electricity

Integrated Processes
Observing
Collecting and recording data
Comparing and contrasting
Communicating
Predicting
Identifying and controlling variables
Inferring

Materials
For each group:
28 gauge wire (see *Management 1)*
two 15-cm strips of 20 gauge copper wire
clay
baby food jar
cardboard
bell wire
steel wool (see *Management 4)*
incandescent light bulb

For the class:
6-volt lantern battery
alligator clips (see *Management 2)*
Thomas Edison: The Great American Inventor by Louise Egan (see *Curriculum Correlation)*
flashlight bulb
bulb holder

For each student:
student book
large rubber band
recording sheets

Background Information
Humphry Davy experimented with electricity and invented an electric battery in 1800. When he connected wires and a piece of carbon to his battery, the carbon glowed (incandesced), producing the first human-made electric light. Many years later, Thomas Alva Edison experimented with thousands of different filaments to find just the right materials that would glow well and be long lasting.

In this activity, students will construct model light bulbs, and experiment with various metals as Edison did to find which materials make the best filaments.

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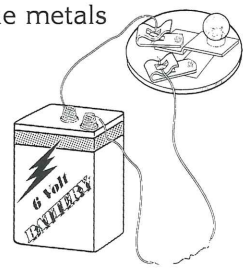
The filaments will light or not light because of resistance, a force that tends to oppose or retard motion. Students will have experienced resistance if they have ever walked through water. Water creates a greater resistance than air, making it harder to walk through. They get hot and may even turn red if they walk far enough in deep water. As students experiment with various light bulb filaments, the electricity flow will encounter different amounts of resistance as it passes through the metals. The resistance that it encounters is based on the type of metal and diameter of the wire. As the electric current passes through the wires, it makes the wires warm. If the electric current meets enough resistance, the wire will get so hot that it glows red- or even white-hot.

Management

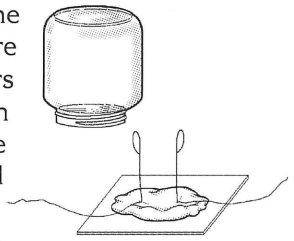
1. Picture frame wire works well and can be purchased at a local department store. The wire comes as several strands wound together; these strands should be unwound before distributing them to the students.
2. Paper clips can be used in place of alligator clips, or the wires can simply be held so that the exposed metals touch.
3. If the wire (filament) glows too brightly and burns through too fast, suggest that students use a longer piece of wire (more ohms), or replace your 6-volt battery with two or three D-cells hooked in series (less volts).
4. It is suggested that you allow students to test the following wires for filaments: steel wool (thicker gage and not copper), copper wire, picture frame wire, bell wire, paper clips, small thin finishing nails, wire strands from inside an old lamp cord, and springs from ball point pens.
5. **Don't connect a wire across the terminals of a 6-volt battery. It makes the battery get hot and drains its energy. It also makes the wire hot, and can cause burns and possible fires. It can make lithium batteries boil inside and burst.**
6. Prior to the lesson, prepare a testing area by stripping both ends of two 24-cm pieces of bell wire and attaching one end of one wire to the positive pole of the 6-volt battery and one end of the other wire to the negative pole of the battery. To test each filament, you will touch the free ends of the wires to the two copper wires on the student model bulb. For safety purposes, use one battery source to test light bulbs. The testing area should be managed by the teacher. You may choose to set up more than one of the battery sources to allow multiple groups to perform tests at one time.

7. To demonstrate that all of the metals being tested will conduct electricity, attach a bulb holder, bulb, and third wire to the 6-volt battery as shown. Bulbs and holders can be purchased from AIMS.



Procedure

1. Discuss *Thomas Edison: The Great American Inventor* by Louise Egan.
2. Distribute copies of the student book on the history of the light bulb. Assist the students in assembling the books by folding the pages into fourths, placing one page inside the other, and wrapping the rubber band around the center of the folded pages. Allow time for the students to read the mini book.
3. Ask the students what part of the light bulb scientists worked hardest to improve, based on their reading. [filament] Discuss why they think scientists put so much time and energy into developing the filament.
4. Distribute a commercial light bulb and the student pages to each group. Ask the students to observe the bulb. Instruct them to make a sketch of the light bulb and record their observations first on the student recording sheet.
5. Tell the students that they will be constructing a model light bulb. Distribute one baby food jar, a golf ball-sized ball of clay, one six-centimeter square of cardboard, and two 15-centimeter pieces of copper wire to each group.
6. Have the groups soften the clay by rolling it around in their hands. When the clay is pliable, instruct them to flatten it into a pancake and place it onto the cardboard square.
7. Tell the students to form a loop in one end of each of the two copper wires. Have them bend the wires approximately five centimeters from the loop to form an "L." Have the students place the two copper wires into the clay so that the loops are about three centimeters apart, and the ends with no loops are on opposite sides of the cardboard square.



8. Ask the students to gently invert the jar and place it over the copper wires. Have the students sketch their model light bulbs on the recording sheet. Tell them to observe and record similarities and differences between the model and the commercial bulb. Ask the students what is missing from their model. [filament]

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9. Explain to the students that they will be testing different materials to see what makes the best filament.
10. Show the student the power source that you will be using to test bulbs.
11. Gather the class around the battery. Display the materials they will be testing as possible filaments for their bulbs. Show the students that each metal being tested is a good conductor of electricity by touching the loose ends of the circuit containing the bulb and bulb holder to the ends of each metal. The bulb should light each time, demonstrating that the metal is a good conductor of electricity.
12. Distribute approximately six centimeters of each of the suggested wires, a paper clip, finishing nail, etc.
13. Explain to the students that they will be attaching the filament to the two loops of the copper wire. Tell them they may choose to make a coil out of the wires they are testing by wrapping it around the end of a small wire and then sliding it off, or they may choose to leave the wire straight when they attach it.
14. When each group has their bulb prepared with one of the filaments, allow them to bring it to the testing area. Have them attach the wires to their copper wires and observe the results. Ask the group to then return to their desks, record their results, and prepare the next filament.
15. When all groups have tested all of the materials, ask them to decide which burned the longest and which gave off the brightest light. Discuss their results. Note similarities in those that glowed. [thin, silver, etc.]

Discussion

1. How was your model light bulb similar to a commercially made bulb? ...different?
2. Which filament material created the brightest light? ...longest lasting light?
3. What problems, if any, did you encounter while trying to get the bulb to light?
4. What did you learn from this experience?
5. What, if anything, surprised you about the materials that you tested?

Curriculum Correlation

Egan, Louise. *Thomas Edison: The Great American Inventor*. Barron's Educational Series. New York. 1987.

This biography examines the life and achievements of the inventor Thomas Edison.

Extension

Encourage students to look for other items that would make good filaments. Allow them to bring them in and test them.

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(RELAY, cont. from page 30.)

solids into the containers. Each team should have its own set of solids and sorting containers. The number of solids in each area should be equivalent to the number of students on each team.

4. Have one student model running to a collection box, taking a solid, running to a sorting area, correctly sorting it into the correct container, and running to touch the next person on his/her team.
5. Explain that when each member of the team has run, sorted an object, and returned to the line, that team is finished. The first team to finish is the winner.
6. After playing the game several times with the various sorting labels, take the objects in the bags and organize them into a real graph. Discuss what students notice about the objects they sorted.

Discussion

1. How did you decide which container to sort your solid into?
2. Which solid did we sort the most of? Why might this be the case? [There are more examples of that type of solid in the real world.]
3. Were there the same number of each solid in the big box for us to choose from? [no]
4. Why do you think we got more of one type than another?
5. Are there any shapes we have studied that were not in the collection? Why or why not?
6. Can you think of other ways we could have sorted the solids? [Straight sides, curved sides, number of corners, etc.]
7. What solids would you like to add to the collection for the next time we play the game?

Extension

Have students search their homes and the playground for interesting examples of spheres, cylinders, prisms, cubes, and cones. After collecting the solids, the students can compare and sort the solids in various ways. They will begin to notice similarities and differences in the various shapes as they sort and sort again.

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Who Turned on the Light?

In 1903, **Willis Whitnew** invented a metal-coated carbon filament that would not make the inside of a light bulb turn dark. Later, in 1906, the General Electric Company patented a method of making tungsten filaments that were used in incandescent light bulbs.

8

7

In 1879, **Thomas Alva Edison** invented a carbon filament that burned for forty hours. He later improved his light bulb until it could last for over 1200 hours using a filament derived from bamboo.

2

In 1908, an English scientist named **Humphry Davy** developed an electric battery to which he connected two wires with a charcoal strip between their ends. The charged carbon (charcoal) strip glowed, producing light. This was the first incandescent electric light.

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In 1829, **Warren de la Rue** put a platinum coil inside a tube and removed most of the air. He then passed an electric current through the coil, causing it to glow. His lamp design worked, but because platinum is so expensive, it was not practical for wide-spread use.

3

Edward Shepard invented an arc lamp in 1850. This electrical incandescent light used a charcoal filament.

4

The first true light bulb was invented by **Henry Goebel**, a German watchmaker, in 1854. To create his light, Goebel used a filament of carbonized bamboo which he placed under a glass bulb.

5

In 1878, the English physicist **Sir Joseph Wilson Swan** invented an electric light using a filament made from carbonized paper. The light glowed for 13.5 hours.

6

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Fiddling with Filaments

Sketch the commercial light bulb.

Description:

Sketch the model light bulb.

Description:

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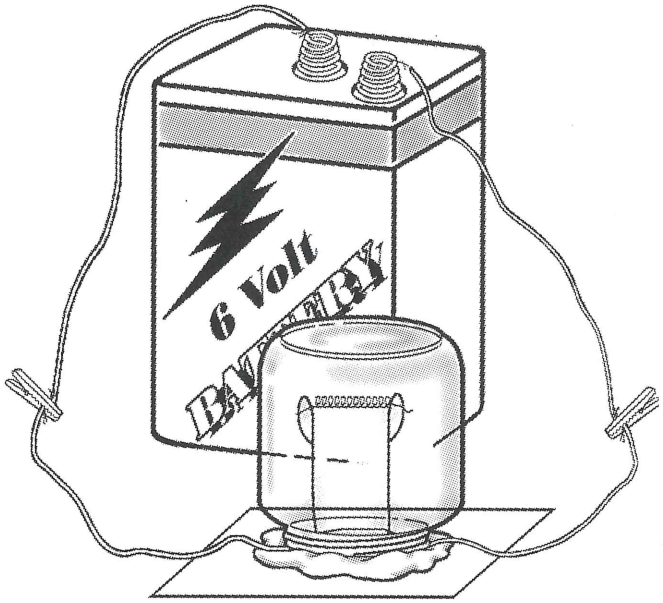
Fiddling with Filaments

Record each material tested, the design of the filament, and the results in the table at the bottom of the page. Use the space below to write your generalizations about the different tests. Which filament(s) seemed to work best? Which design(s) seemed to work best? Why do you think this is?



Generalizations:

Material Tested	Design	Results

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Puzzle Corner/Maximizing Math Switching Sequences

by Michelle Pauls

The *Puzzle Corner* and *Maximizing Math* activities this month are two parts of one problem—a variation of a teaser that appeared in the March, 2003 *Games* magazine. The original version describes a five-volume set of books that have been reshelved in descending order, from five to one. The challenge is to put the books in order from one to five using the fewest possible number of moves. Each move consists of changing the location of two adjacent books. Any gap created by moved books is closed immediately.

Our version uses number cards for the numbers one through four, and offers the five-number version as an extension. While a single solution was given in *Games* for the original version, it turns out that there are multiple solutions, both to the five-number version and to our four-number variation. Additionally, there are many patterns in the solutions to be explored, making this a rich and valuable problem.

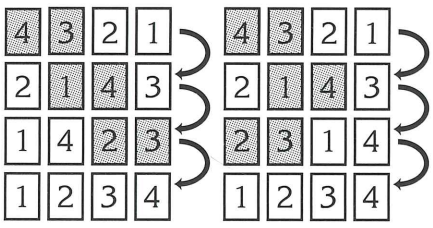
For the *Puzzle Corner* portion of the activity, students are challeged to take number cards arranged to read 4 3 2 1 and rearrange them to read 1 2 3 4 in the fewest number of moves. Each move must take two adjacent cards and place them in a different location. Whenever cards are moved, any gap they leave behind is closed. Once the minimum number of moves is determined, the challenge becomes to find every possible solution using that number of moves. I would encourage you to try this problem for yourself right now. Make four cards numbered 1, 2, 3, and 4, and arange them in descending order. See how many moves it takes to you put them in ascending order, each time moving two adjacent cards together. This will allow you to experince the joy of problem solving as well as give you a better understanding of what your students will go through when completing this problem.

Hopefully you were able to reorder your number cards in three moves—the minimum possible. Once this discovery of the minimum number of moves has taken place, the next challenge is to discover every possible way to re-order the cards in this number of moves. A page for recording solutions is provided, but there are fewer spaces than the total number of solutions. Students can either use the back of the paper for further recording, or you can make additional copies of the recording page available. It may be necessary to have students work on this problem over the course of several days in order for them to come up with all of the solutions.

Once students believe they have found all of the possible solutions, they will be ready to move on to the *Maximizing Math* portion of the activity. Begin by having students get into small groups and compare their solutions. As a group, they should develop a list that includes all solutions found among them. Distribute the student pages and give students sufficient time to respond to the questions and complete the table of solutions. Close with a time of whole-class discussion where groups share their solutions and discuss the patterns they see.

Discussion of Patterns

There are many fascinating patterns that can be explored in the solutions. Of the 16 possible solutions, only four are truly unique in the sense that they move different number cards to produce different orders of numbers each move. Of the remaining solutions, four pairs move the same two cards for each move, but with different number orders resulting. The other four pairs move different number cards, but result in the same number orders. For example, in the solutions below, the same combinations of numbers are moved—four and three, then one and four, and finally two and three. However, the third number order produced by these moves is different—2 1 4 3 to 1 4 2 3 and 2 1 4 3 to 2 3 1 4. (The shaded spaces indicate the number cards that were moved each time.)



In the following solutions, the reverse is true. Different number cards are moved during one

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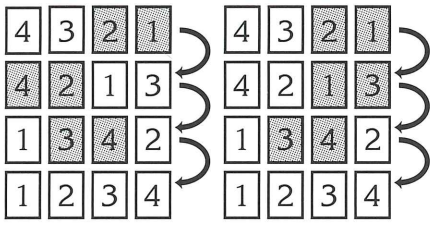
of the turns, but the same number sentences are produced each time.



It is fairly simple to prove that you have indeed found all possible solutions. If you begin with the starting number order of 4 3 2 1, you can determine all of the possible combinations that can result by moving two cards at a time. These possibilities are illustrated in the table below.

Beginning with 4 3 2 1

Move #s	Possible Results
2 1	2 1 4 3 4 2 1 3
3 2	3 2 4 1 4 1 3 2
4 3	2 1 4 3 2 4 3 1

Notice that two of the possible results are duplicates of each other—the order 2 1 4 3 can be reached by moving either the two and the one or the four and the three. This means that there are only five possible number orders which can result from a single move of the beginning sequence.

If you now repeat this process beginning with the ending order of 1 2 3 4, you will generate another five possibilities, outlined in the table below. (Again, two of the orders are the same.)

Beginning with 1 2 3 4

Move #s	Possible Results
1 2	3 1 2 4 3 4 1 2
2 3	2 3 1 4 1 4 2 3
3 4	3 4 1 2 1 3 4 2

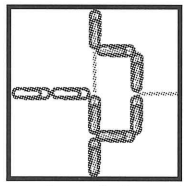
To obtain every possible solution, all that is necessary is to take one of the two lists generated, and repeat the process used to generate the list. That is, take each new sequence, and determine all of the possible sequences that could result from it by moving two numbers.

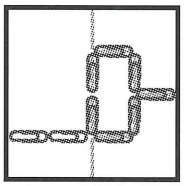
For example, the sequence 3 1 2 4 could become 2 3 1 4 or 2 4 3 1 by moving the three and the one, or 3 2 4 1 or 2 4 3 1 by moving the two and the four. (You would not move the one and the two because those were the numbers moved to generate the sequence.) Of those three unique possibilities, two—2 4 3 1, and 3 2 4 1—are in the list of results found in the first table. This means that it is possible to go from the beginning sequence to the solution using each of these two sequences.

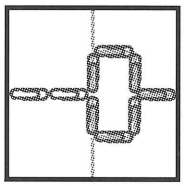
These are just some of the intriguing patterns that your students can discover while working on this problem. As an extension, repeat the problem using the numbers one through five and compare the results.

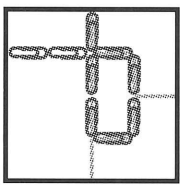
Last Month's Puzzle

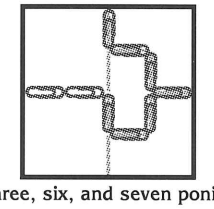
Penning Ponies started with 16 ponies divided into four pens containing eight, three, three, and two ponies respectively. Students were challenged to move only two paper clips (fence sections) to get different numbers of ponies contained in three-pen arrangements. One possible solution for each arrangement is shown below.

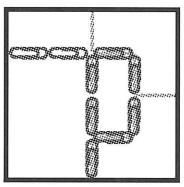

Four, six, and six ponies


Two, five, and nine ponies


Two, seven, and seven ponies


Two, two, and 12 ponies


Three, six, and seven ponies


Two, six, and eight ponies

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Switching Sequences

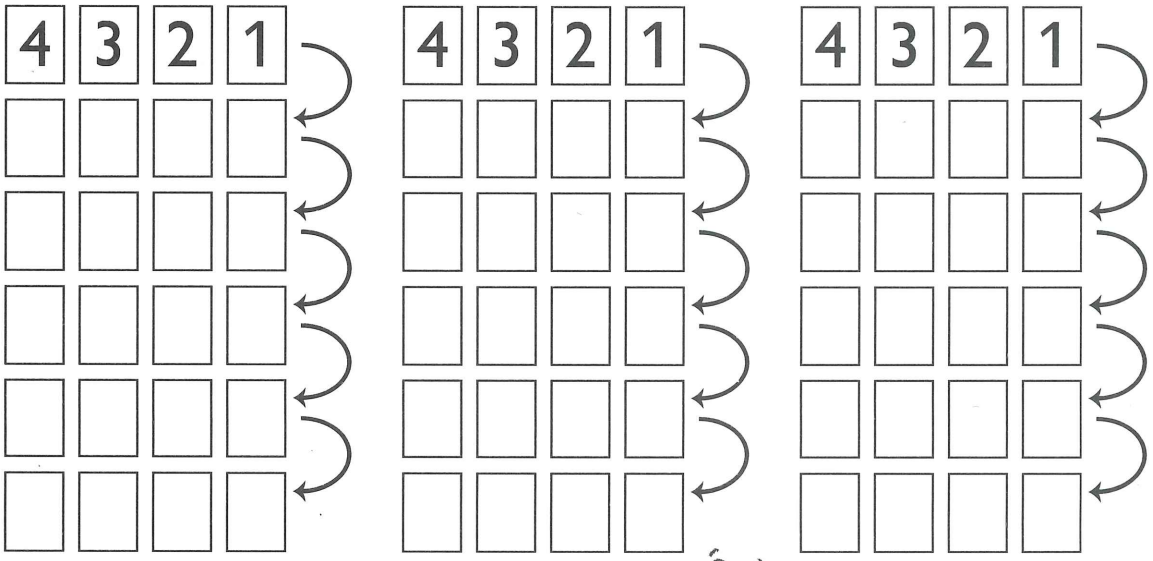
Puzzle Corner

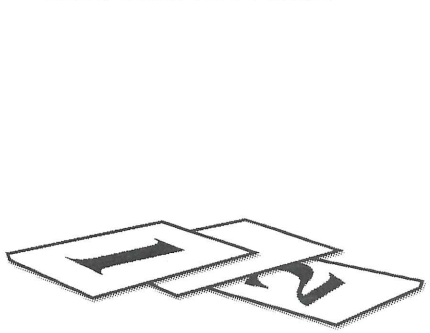
Lay your number cards in a row so that they read 4 3 2 1. Your challenge is to rearrange the cards so that they read 1 2 3 4 using the fewest number of moves. You must always move two cards at a time. The two cards moved must be next to each other. Whenever cards are moved, any gap they leave behind is closed.

Try it now and count how many moves you make. Record this number below.

Try it again, and see if you can do it in fewer moves. Keep trying until you can't do it in any fewer moves. What is the fewest number of moves it takes to re-order the numbers?

Once you find the fewest number of moves possible, see how many ways you can rearrange the cards in this many moves. Record each solution in the spaces provided here and on the next page. Shade the number cards you moved each time and write the new arrangement that resulted in the spaces below.





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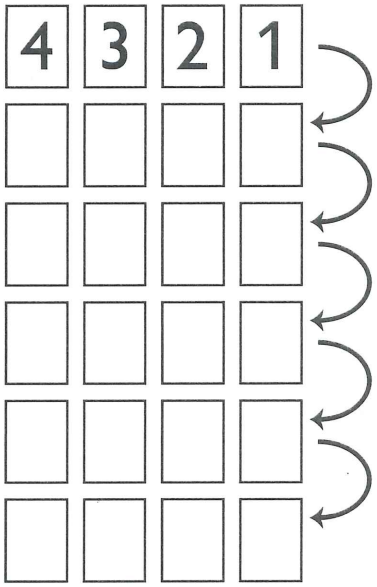
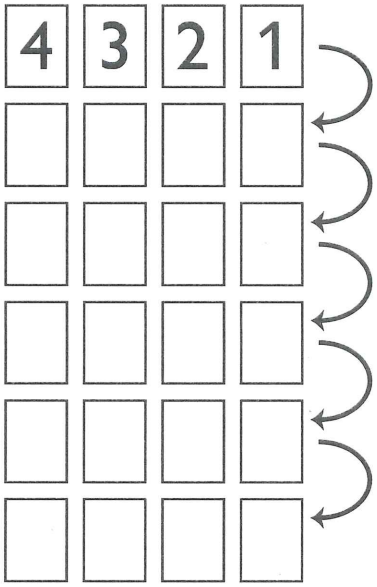
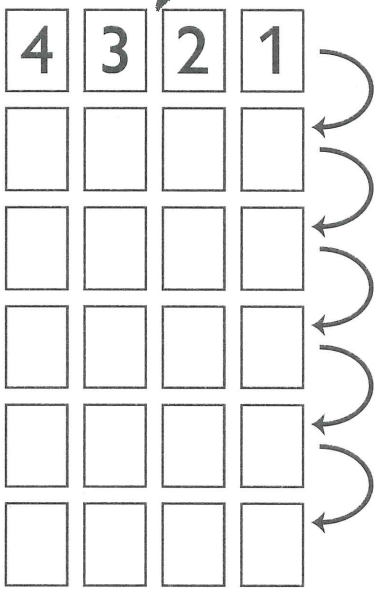
Switching Sequences

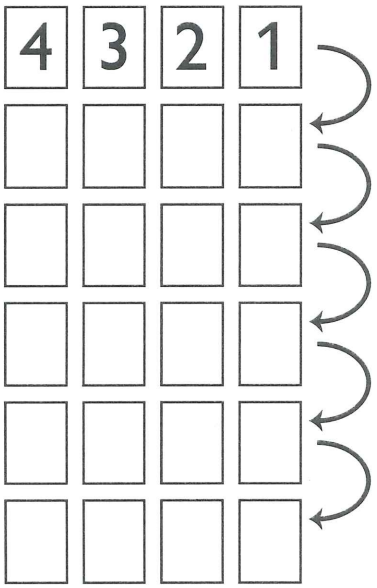
Puzzle Corner

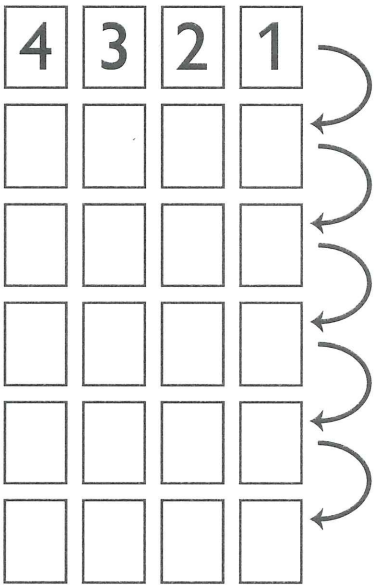
To record your solutions, shade the number cards you moved each time and write the new arrangement that resulted in the spaces below. If you need more room, use the back of this paper.

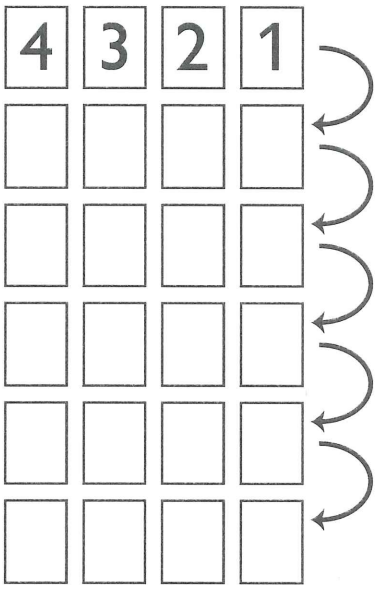


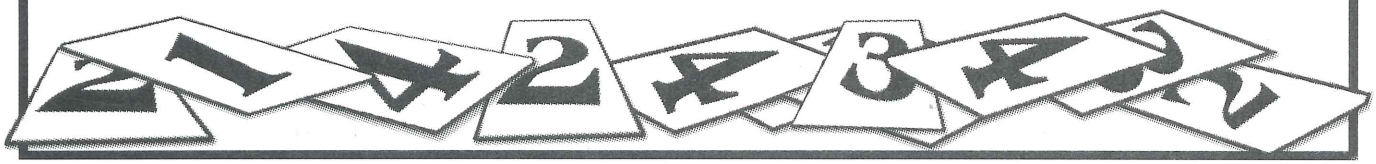












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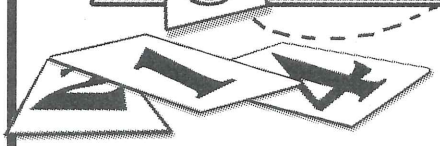
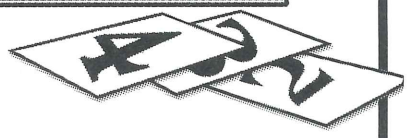
Switching Sequences



Maximizing Math



1. What is the fewest number of moves in which you can rearrange four numbers? How do you know?

2. How many solutions did you discover? Do you think you have found them all? Why or why not?

3. Look at your solutions and describe any patterns or interesting things you notice.

4. Arrange the cards 4 3 2 1. Record every possible order that could result from moving two adjacent cards.

5. Arrange the cards 1 2 3 4. Record every possible order that could result from moving two adjacent cards.

6. Using these two lists, describe how it is possible to determine every solution for this problem.

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Switching Sequences

Maximizing Math

Fill in the table below with each possible solution. Organize the solutions in a logical way and explain your organization below.

Starting Order	Move Cards	Second Order	Move Cards	Third Order	Move Cards	Final Order
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4
4 3 2 1						1 2 3 4

How I organized my solutions:

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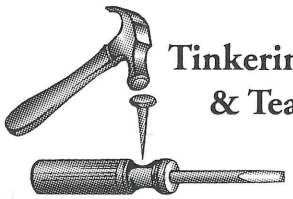
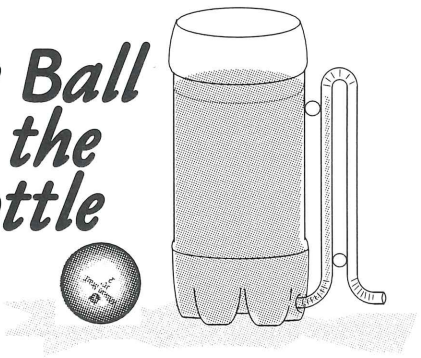


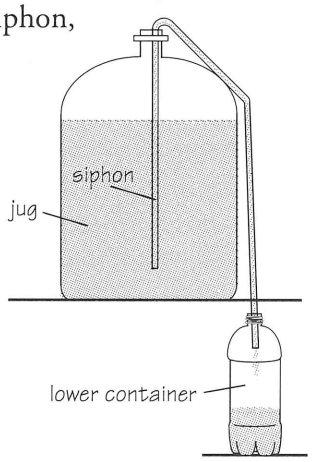
Tinkering, Toys, & Teaching

The Ball in the Bottle



by Jim Wilson

A *siphon* is a flexible tube used to transfer a liquid from one container to a second container placed at a lower level. I use a siphon to drain the water from a 5-gallon glass jug I keep in my office as an aquarium. The siphon tube is nothing more than a piece of plastic tubing. To start the siphon, I place one end of the tube in the container I want to drain and the other end in my mouth. I draw water from the jug until it flows freely into the lower container.



The siphon was known to Hero of Alexandria (see *Hero's Fountain* in Volume XVII, Number 7) over two thousand years ago. In the following project, a siphon is built into a container so that the container empties completely when filled with water to a predetermined level.

Materials

20-ounce plastic bottle
Three plastic flexible drinking straws
Golf ball
Waterproof clay (plastic based), five-minute epoxy, or low temperature glue and glue gun

Tools

Nail with a sharp point
Scissors
Ballpoint pen

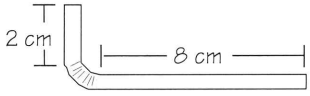
Removing the Label from a Plastic Bottle

Follow these steps to make the plastic bottle clean and bright.

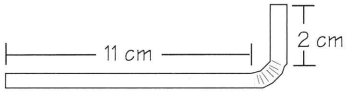
1. Wash and rinse the bottle. Fill the bottle with hot (not boiling) water and screw the cap on tightly. The hot water loosens the glue holding the label.
2. Cut across the label with the tip of a pair of scissors.
3. Carefully peel the label from the bottle. If the label still sticks to the bottle, lay the bottle on its side, lift one flap of the label, and direct hot air from a hair dryer at the point where the label meets the bottle. As the label loosens, it is easily pulled from the bottle.
4. Use a commercial "goo" remover or lemon juice to remove the residue of glue left after removing the label. Rinse the goo remover off the bottle.

Constructing the Siphon Bottle

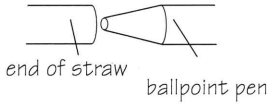
1. Stretch the flexible joint in a straw to its maximum length. Bend the short end of each straw to form a right angle. Trim the ends of the straw to lengths of two centimeters and eight centimeters.



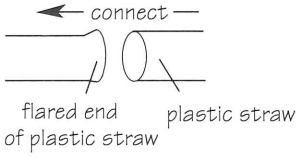
2. Trim the ends of a second straw to eleven and two centimeters.



3. Use the tapered end of a ballpoint pen or pencil to flare the 8-cm end of the first flex straw. To do this, push the pen into the straw and gently rotate it to produce the flared end.



4. Insert the 2-cm end of the 11-cm flex straw into the flared end. Push to get a tight seal.



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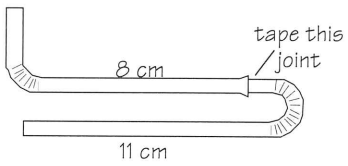
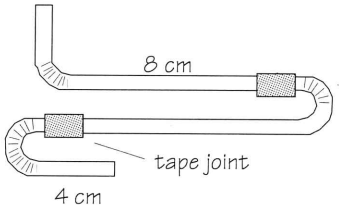
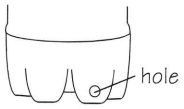
5. Adjust the straws so that they look like the straws in the following diagram. Wrap a short piece of transparent tape around the joint to keep it from separating.



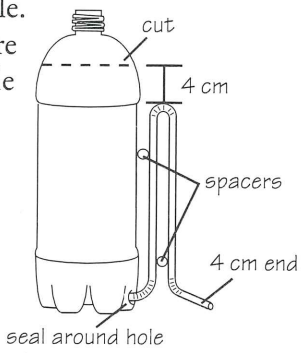
6. Repeat this process by trimming the ends of a third straw to dimensions of two and four centimeters. Flare the end of the 11-cm straw. The 2-cm end is then attached to the flared end of the 11-cm straw.



7. Use the sharp point of a nail to punch a hole in the bottom of the bottle. Enlarge and round out the hole by inserting the end of the ballpoint pen into the hole and rotating the pen.

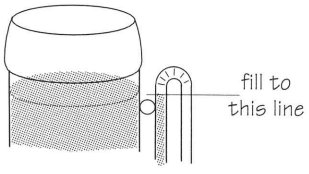


8. Insert the short, 2-cm straw end into the hole in the bottom of the bottle. Seal around the area where the straw enters the bottle with waterproof plastic clay, five-minute epoxy, or glue from a low-temperature glue gun. Cut short sections of plastic straw to use as spacers and glue or tape them into place as indicated. Cut the top off the bottle at a distance of four centimeters above the top of the siphon.

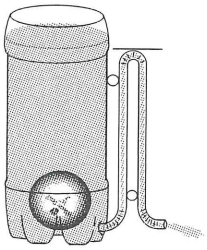


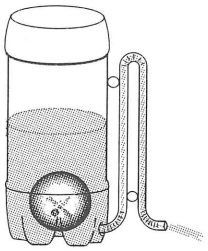
How to Use the *Ball in the Bottle*

1. Fill the bottle with water up to just below the top curve in the straw tube.



2. Gently drop the golf ball into the bottle. The golf ball will sink and raise the water level in the bottle. Water will begin to siphon out of the bottle.
3. The water continues to flow even after the water level in the bottle dips below the level of the top of the siphon. The water will continue to drain from the bottle until it reaches the inlet of the siphon.



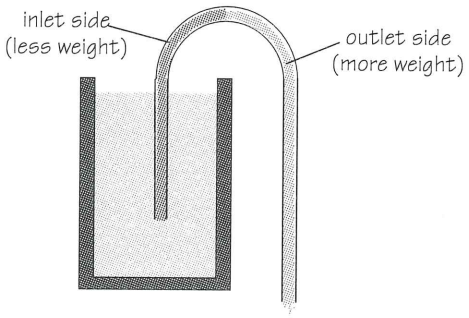


What's the Science?

The bottle is designed to be an automatic, self-siphoning liquid container.

Two forces pull the liquid over the top of the siphon; the liquid's own intermolecular force, and the weight difference between the inlet and outlet side of siphon. The intermolecular force is called *cohesion.*

With more fluid on the oulet side than the inlet side, the cohesive force pulls the fluid up and over the siphon. Although any siphon is more efficient at atmospheric pressure, it will work in a vacuum. Popular belief incorrectly holds that it is atmospheric (air) pressure that pushes the fluid up and over the top of the siphon.



To illustrate that the pressure at the top of the siphon is less than air pressure, make a small hole in the top with a pin and observe that air enters the hole and forms bubbles in the fluid.

The presentation

We know that great food chefs use *presentation*—color, shape, and texture—to set the stage for the

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coming taste sensations. The same is true for a good science puzzle. The siphon effect can be easily and quickly demonstrated but, if a little time is taken to present the problem, the results are better appreciated.

The AIMS office staff is always interested in the science and mathematics ideas that are the bread and butter of our organization. To illustrate one way to present the siphon bottle puzzle, I set the bottle on the office break room table. First, I placed the siphon bottle in the center of an aluminum pie tin (to catch the water). I then tested various water levels and made a small mark on the bottle at the level where it siphons when the golf ball is put inside. I put the golf ball in the pie pan and added water to the level of the mark. I also added a few drops of red food coloring to the water to make it easier to see. I then wrote the following on a card and placed it next to the pan.

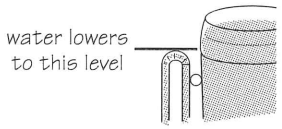
Predict what you think will happen when the golf ball is gently dropped into the water. Vote for either A, B, C, or D by placing a simple tally mark (/) under the letter of your choice.

A. The water will rise in the plastic bottle but nothing else will happen.

B. The water will rise in the bottle, spill over, leaving the bottle full of water.

C. All of the water will leave the bottle through the straw tube.

D. Water will leave through the straw tube until the level in the bottle reaches the top curve of the straw tube.



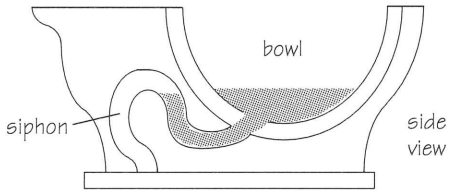
Anyone that saw the display was invited to respond to the question by choosing one of the four responses. Most chose response D. During afternoon break we gathered around the table and dropped the ball in the bottle to settle the question and share explanations.

Almost everyone enjoys a good science puzzler and students are no exception. So, make a siphon bottle, keep it on your desk, and enjoy sharing its operation with students.

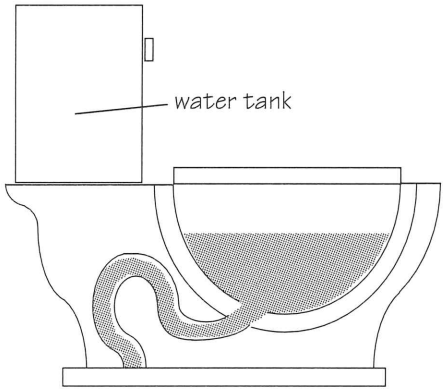
One Last Thought

It's a rare person that recognizes Hero's ancient self-emptying bottle in its modern form—the ordinary toilet.

A toilet is a *bowl siphon*. The distinctively curved mold lines of the siphon can easily be seen in most porcelain toilets.



When the toilet is flushed, water from the tank empties into the bowl causing the water level to rise to the top of the siphon. As soon as this happens, the bowl empties.



The Ball in the Bottle is nothing more than a bowl siphon. Instead of putting the ball in the bottle, pour a glass of water into the bottle until the siphon starts.

In the next column, we will construct a simple mechanical device that demonstrates the action of both a First- and Third-class lever.

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Selective Service

revised by Betty Cordel

Topic
Osmosis, Selectively-permeable membranes

Key Question
How can an egg show us how materials are transported from place to place?

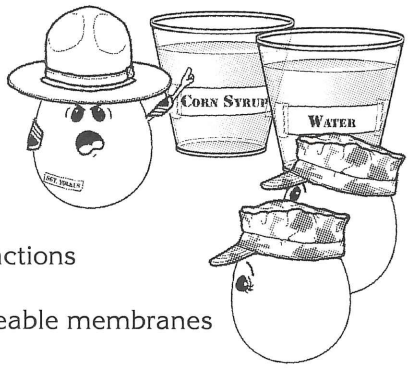
Learning Goals
The students will:
1. observe the evidence of a chemical reaction,
2. observe the passing of materials through a membrane, and
3. relate this process to transport systems in living organisms.

Guiding Documents
Project 2061 Benchmarks
- *One way to make sense of something is to think how it is like something familiar.*
- *Use numerical data in describing and comparing objects and events.*

NRC Standards
- *Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.*
- *Use appropriate tools and techniques to gather, analyze, and interpret data.*
- *Objects have many observable properties, including size, weight, shape, color, temperature, and the ability to react with other substances. Those properties can be measured using tools, such as rulers, balances, and thermometers.*

*NCTM Standards 2000**
- *Understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute*
- *Collect data using observations, surveys, and experiments*
- *Represent data using tables and graphs such as line plots, bar graphs, and line graphs*
- *Describe the shape and important features of a set of data and compare related data sets, with an emphasis on how the data are distributed*

Math
Measurement
circumference
mass
Estimation
Graphing



Science
Physical science
chemistry
chemical reactions
osmosis
selectively-permeable membranes
Life science
transport of materials

Integrated Processes
Observing
Comparing and contrasting
Collecting and recording data
Analyzing data
Drawing conclusions
Applying

Materials
Eggs (see *Management 3)*
Vinegar (see *Management 5)*
Plastic cups (see *Management 4)*
Light corn syrup
Water
String, 30 cm per group
Balances
Metric masses
Metric rulers
Paper towels
3" x 5" index cards (see *Management 6)*

Background Information
In all living organisms, the materials involved in such processes as respiration, nutrient transfer, waste removal, etc., must be able to move from place to place. In order to do this, they have to be able to move across membranes. It is also necessary that these membranes allow only specific materials to cross them; they need to be selective. A selectively-permeable membrane is one that allows only certain materials to cross it. These membranes are the gatekeepers that let things in or out.

Selectively-permeable membranes, also called semi-permeable membranes, make it possible for

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minute particles to pass through the walls of capillaries, intestine villi, and cell membranes. Some examples in extreme simplicity: Oxygen from the lungs passes through capillary walls to be transported by the blood to all parts of the body. Carbon dioxide passes from the cells through the capillaries and is transported by the blood to the lungs to be exhaled. Broken down food particles in the small intestine pass from the intestinal villi into the blood stream to be transported throughout the body to nourish it.

In this experience, students will use vinegar to decalcify an egg. They should recognize that the bubbles that are produced are evidence that a chemical reaction (evolution of a gas) is occurring between the acid in the vinegar and the calcium in the eggshell. Once the egg has been decalcified, the egg is left intact with just the rubbery membrane holding it together. This membrane is a selectively-permeable membrane that allows only particles of a certain size to pass through.

Some of the decalcified eggs will be placed in corn syrup. After a short period of time, students will notice that the egg is shrinking in mass and circumference. This is because of osmosis—the passing of water molecules through the selectively-permeable membrane from areas of high concentration of water into areas of lower concentration. This higher water content of the egg means that its water will pass through the membrane into the corn syrup. Have students notice that the yolk does not pass through this membrane.

Students will also place some of the decalcified eggs into a container of water. Because the container of water is of a higher water concentration than the water in the egg, the water from the container will pass through the egg's membrane into the egg. Students will notice that the egg gains both mass and circumference.

Management

1. This activity is divided into three parts. *Part One*—the decalcification of the eggs. *Part Two*—the passing of water from the egg into the corn syrup and the passing of water from the container into the egg. *Part Three*—the playing of a Red Rover-type game with students to reinforce the idea of a selectively-permeable membrane.
2. Divide the class into groups of three of four students.
3. Each group will need at least two decalcified eggs. You may want to have extras available in case of breakage. Warn students that they must be careful with the eggs; even though the membranes are tough and flexible, they do break.
4. Each group will need as many plastic cups as they have eggs.
5. White vinegar from the grocery store works well. You may want to cover the tops of the vinegar-filled cups with plastic wrap in order to keep the odor down.
6. Students will need 3" x 5" index cards to make *Pass on Through* and *Don't Pass on Through* labels for *Part Three*. Each student will need one card.
7. The string will be used for measuring the circumference of the eggs. Students will put the string around the "equator" of the egg, mark the spot of overlap, and then compare the length to the centimeter measures on a metric ruler. This will prevent getting corn syrup, etc. on the rulers.

Procedure

Part One

1. Ask the *Key Question* and state the *Learning Goals*.
2. Distribute at least two eggs and two plastic cups to each group. Tell students to write *Egg 1* and *Egg 2* on a piece of transparent tape or masking tape to use as labels for the cups. Students may also want to put a group name on the tape to insure that they get the same eggs with which they began.
3. Have students carry their cups and eggs to a designated place where the eggs will sit in vinegar for about two days.
4. Once the eggs are in place, let students add vinegar to their cups, telling them to add enough to cover the eggs.
5. After two days, review the *Key Question* and the *Learning Goals*.
6. Distribute the first student page. Go over the directions on the page. Ask the students what things they will have to collect in order to complete the page. [eggs and vinegar, balance, masses, string, meter tape, paper towels] Write these on the chalkboard or on the overhead projector so that students can be sure they have gotten all their supplies. Give them two or three minutes to gather everything.
7. Once everyone is back in their seats, ask students what they observe about the eggs and vinegar. [The shells are gone, there is white stuff and bubbles in the vinegar.] Ask them what evidence there is that a chemical reaction has occurred.
8. If there is any shell left on the egg, tell students to gently rub if off. Direct them to drain the vinegar, wash and dry the cups, and rinse the egg. Have them complete the information on the rest of the page. Describe how they should use the string to measure the egg's circumference.

Part Two

1. Distribute the second student sheet. Have students follow the directions for putting one egg in water and one in corn syrup.
2. Discuss the difference between a prediction and a guess. [To make a prediction you must have prior experience on which to base your prediction.] Inform students that they will probably be guessing when they "predict" what will happen next, which is acceptable in this situation.

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3. Have the groups assign one member to be the timekeeper to make sure they are making measurements every ten minutes. Direct them to record the *Start* time mass and circumference from the actual measures they recorded on the first student sheet.
4. After the entire 30-minute period, have students complete the graphs on the third student page and write their conclusions. Make certain that they color code the data by using the color key.
5. Discuss how the selectively-permeable (permeable means some things pass through) membrane allowed something to pass through from the egg into the corn syrup, and the water to pass through into the egg. The membrane was selective in what it allowed to go through.
6. Discuss with the students how living organisms have selectively-permeable membranes. This is how water is absorbed by the root hairs of plants. It is how nutrients are absorbed into the blood stream. It is how oxygen and carbon dioxide get into the blood stream.

Part Three

1. Tell the students that they are going to play a modified version of Red Rover and apply it to selectively-permeable membranes.
2. Divide the class into two teams and give each student one index card. Explain that they will form two lines, facing each other and holding hands.
3. Have one side start by calling to a person from the opposing team to "(Name, Name) we want you to try to pass through." That person then runs toward the other line trying to break through the opposing team. If he or she breaks through, the student writes on his or her index card *Pass on Through* and chooses a member from the opposing team to join his or her team. If he or she fails to break through, the runner writes *Don't Pass Through* on his or her index card and joins the other team.
4. Try to continue the game long enough for every student to have a chance to be the runner.
5. Ask the students how this game is like the egg experiment. What is the significance of the index cards? Have them record their responses on the final student page.

Connecting Learning

1. What evidence did you have that a chemical reaction took place?
2. What was the result of this chemical reaction? [the acid in the vinegar reacted with the calcium and the egg was left without its shell]
3. When you rolled the decalcified egg across your arm and across the paper towel, what did you notice? [It left a wet trail.] Why do you think this happened? [The water in the egg was able to pass through the egg's membrane.]
4. Explain what you observed when you put the decalcified egg in the corn syrup. ...in the water.
5. Why did this happen? [The membrane of the egg lets some things pass through.]
6. What are some examples of selectively-permeable membranes in living things?
7. Explain in your own words how the game of Red Rover is like what happened with the egg.
8. What things passed through the egg's membrane that would be like the students who got the labels *Pass on Through?*
9. What would be something that *Does not Pass Through?*
10. What are you wondering now?

Extensions

1. Let students see what happens if they leave their eggs in corn syrup and water for longer periods of time.
2. Let students select other liquids for their decalcified eggs. What about rubbing alcohol, plaster of Paris, water with food coloring, salt water, sugar water, cola, milk, etc.?

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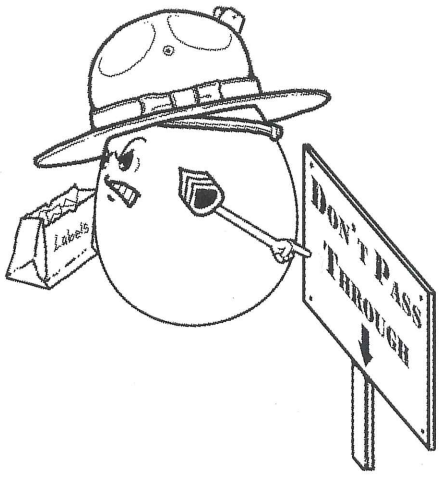

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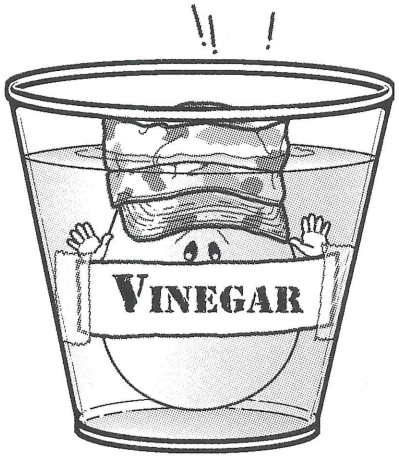
PART ONE

SELECTIVE SERVICE



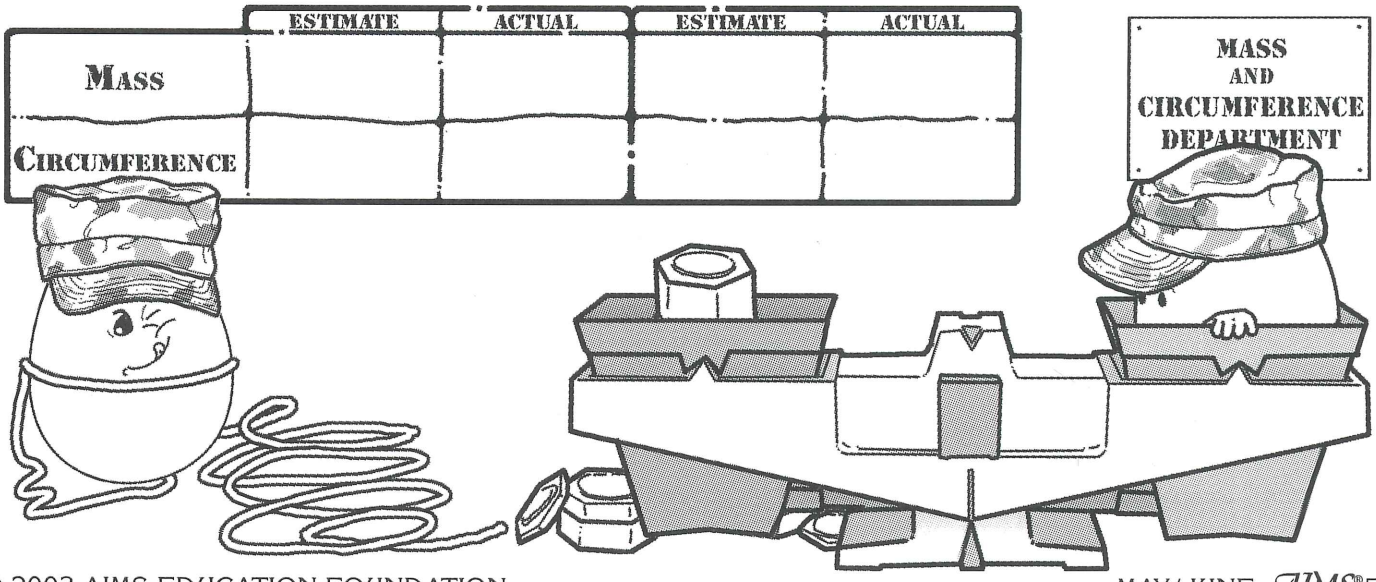
1. First, soak raw eggs in vinegar for about two days. What do you notice about the eggs in vinegar?

2. What do you think is happening to the eggs?

3. Take out one decalcified egg. Handle it with care! Gently blot it dry. Roll it along the chalkboard, a paper towel, and your arm. What do you notice?

4. Gently blot two decalcified eggs with a paper towel. Estimate their masses and circumferences. After you've estimated them, find their actual measures.

	EGG 1		EGG 2	
	ESTIMATE	ACTUAL	ESTIMATE	ACTUAL
MASS				
CIRCUMFERENCE				



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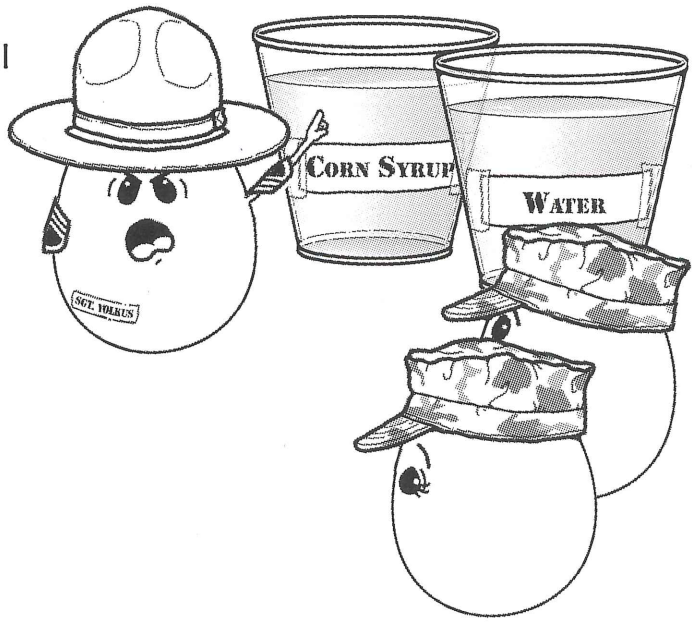
PART TWO

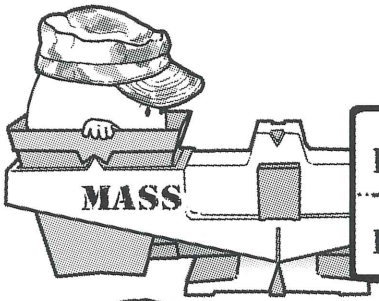
SELECTIVE SERVICE

1. Place one decalcified egg into one cup and the second egg into another cup. Fill the first cup with water and the second cup with corn syrup.
Describe your observations.

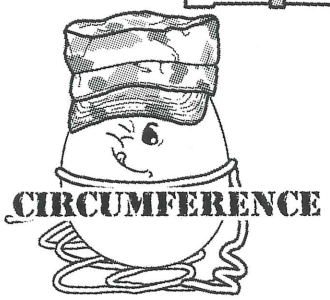


2. Predict what you think will happen.

3. Soak the eggs for a total of 30 minutes. Take them out at 10-minute intervals to find their circumferences and masses. Record your information in the tables.



	START	10 MIN.	20 MIN.	30 MIN.
EGG IN WATER	g	g	g	g
EGG IN SYRUP	g	g	g	g



	START	10 MIN.	20 MIN.	30 MIN.
EGG IN WATER	cm	cm	cm	cm
EGG IN SYRUP	cm	cm	cm	cm

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SELECTIVE SERVICE

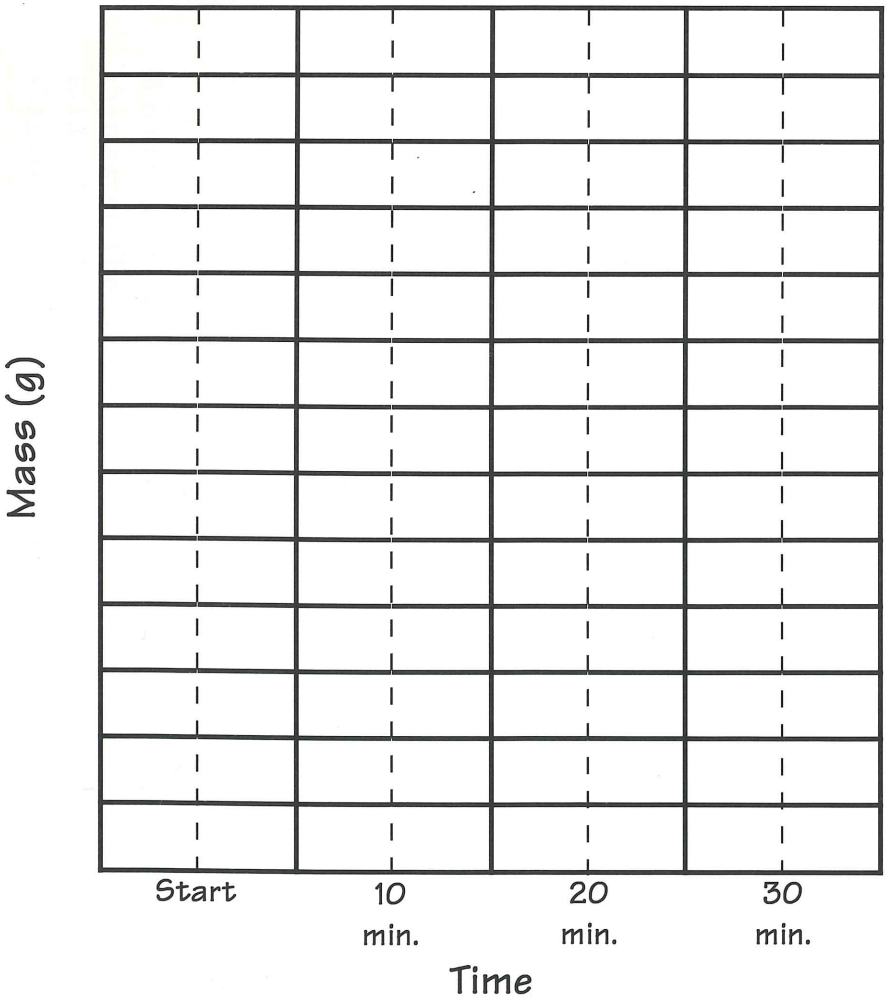
PART TWO

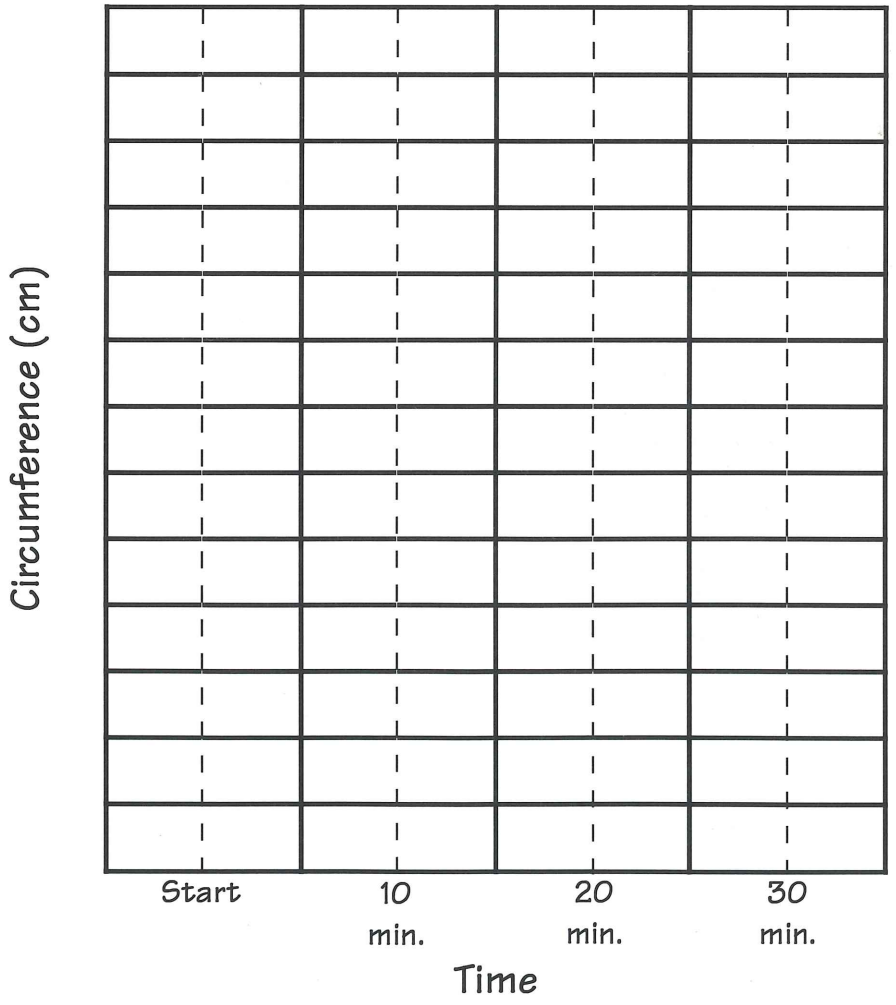
COLOR KEY

= EGG IN WATER

= EGG IN SYRUP

4. Use two different colors to make a bar graph of your data. Fill in the key.



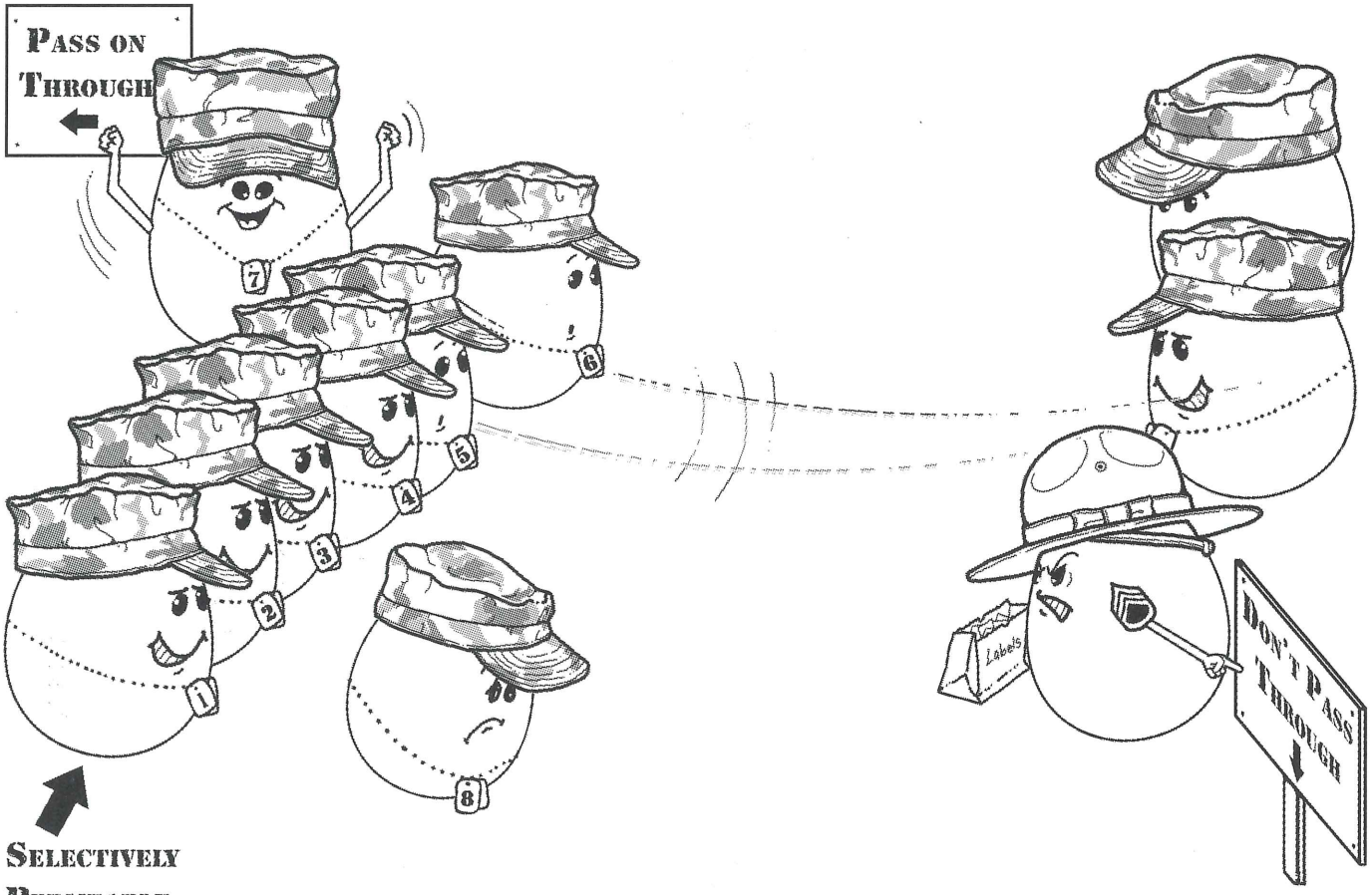


5. Carefully analyze your results. What is your conclusion? (Use the back of this paper.)

Part Three

Selective Service

Red Rover



Selectively Permeable Membrane

How is this game of Red Rover like the eggs in corn syrup and water?

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The Teachable Moment

by Suzy Gazlay

Ketchup

Summer—the season of hamburgers and hot dogs, baseball games and backyard barbecues. Most people would say that hamburgers and hot dogs just wouldn't taste as good without the sauces and other stuff we put on them, although we don't all agree as to which is our favorite. A significant number of people choose ketchup over any other condiment, not only for hamburgers or hotdogs, but also for meatloaf, french fries, and many other foods.

Just what is ketchup? Believe it or not, its origin is related to pickled fish, and for a long time it didn't contain any tomatoes at all. Hundreds of years ago, people in China and Malaysia were pickling fish to keep it from spoiling. Somewhere along the way, they discovered that the brine and spices left over from the pickling process tasted pretty good when used as a dipping sauce. They called it *katchiap* or *ke-tsiap*, meaning "fermented fish sauce." That name probably came from *kechap*, the Malay word for soy sauce. The names we use now—*ketchup*, *catsup*, and *catchup*—have evolved from these words.

During the 1600s and early 1700s, British sailors tasted the tangy sauce and brought it home. It was difficult to find the same ingredients in Britain, so variations were developed from such components as pickled walnuts, mushrooms, kidney beans, anchovies, or lemons. The common ingredient was vinegar, not tomatoes. Only the rich could afford these sauces. Eventually, some enterprising people began bottling the sauces for sale. In 1690, the name *catchup* was first recorded, followed by *ketchup* in 1711 and *catsup* in 1730.

Colonial Americans experimented with the British recipes, using different vegetables and spices. The first American ketchups were tart rather than sweet. The first recorded ketchup recipe appeared in 1727 in a cookbook called *The Compleat Housewife*. The ingredients were anchovies, shallots, vinegar, white wine, lemon peel, pepper, cloves, ginger, mace,

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and nutmeg. Tomatoes didn't come into the picture until the 18th century. Before then, many people believed tomatoes to be poisonous, probably because tomato plants are similar in appearance to deadly nightshade plants. However, tomatoes had been grown and eaten in Central America for several centuries. Eventually their use spread to other locations, including America where they were called "Love Apples."

A 1792 cookbook introduced "tomato catsup," but the recipe was rather difficult. In 1812, James Mease, a Philadelphia scientist, published the first ketchup recipe that was truly based on tomatoes. Three more tomato ketchup recipes appeared in an 1814 cookbook. Variations of tomato ketchup soon followed. New flavors abounded during the following years, including oyster, mussel, elderberry, a combination of horseradish and mushrooms, and a combination of beer, anchovies, and mushrooms. The main ingredients were blended with garlic or onion, spices, and wine or other liquor.

The process of making ketchup was long and tedious, requiring almost a day of work. When a New England farmer named Jonas Yerkes began bottling ketchup in the 1830s, housewives were very happy to be able buy quarts and pints ready-made at a price ranging from 33 to 50 cents a bottle. Before long, Americans were selling their tomato ketchup in Britain. Although it was very different from the already popular British ketchup—a thin, transparent sauce made from mushrooms—they were asked to change the name to "tomato chutney."

The first commercial ketchup was marketed in 1834 by Bunker & Company in New York. Their recipe used the leftovers from commercial canned tomato production—trimmings and rotten, green, and diseased tomatoes. In 1848, some ketchup producers came under fire for using coal tar to bring out the red color. Obviously, this was long before the Pure Food Act and FDA standards!

Meanwhile, some ketchup producers catered to the American taste for sweet foods and began making tomato ketchup with vinegar, sugar, and cinnamon among the ingredients. The new version soared in popularity. In the 1870s, an enterprising new company named Heinz added "sweet tomato ketchup" to its list of products. By 1900, there were more than 100 different manufacturers producing ketchup.

Experimental ketchups have been made from just about any likely components, particularly fruits and vegetables. Grapes, cucumbers, cranberries, cherries, apples, and apricots are among the many flavors produced over the years. Some of earliest flavors such as walnut, oyster, mushroom, and anchovy have reappeared from time to time. Most have had the common features of a thick texture and a salty taste, although some—like tomato ketchup—taste somewhat sweet rather than salty. Recipes for many of these old and new varieties of ketchup can be found in cookbooks and on the Internet, but tomato ketchup is still the best known, most popular, and now the only kind that can usually be purchased in most grocery stores.

Today's classic tomato ketchup is basically the same recipe used when it was first produced commercially by Henry J. Heinz in 1876. Government standards specify cooked and strained tomato sauce (or puree), vinegar, sugar, salt, onion or garlic flavor, and various spices such as cinnamon, cloves, mace, allspice, nutmeg, ginger, and cayenne pepper. Low sodium, light, and organic ketchups are also available. Regional variations include garlic, smoky, peppercorn, horseradish, onion, and mesquite. One version is made from bananas and colored red to look like the "real" thing.

Even the thickness is regulated. Government standards established in 1953 dictated that Grade A ketchup had to flow nine centimeters in 30 seconds. In 1991, new

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standards set the Grade A rating at a flow rate of three to seven centimeters in 30 seconds.

As well known and well loved as ketchup is, it is no longer our most popular condiment. In recent years it has been surpassed by salsa, reflecting Americans' growing taste for hot and spicy food. However, interest in making homemade ketchup has increased in recent years.

Interesting Facts

- Ketchup can be found in 97% of the households in the United States. Only salt, sugar, and pepper are found as frequently.
- A tablespoon of ketchup contains 16 calories and no fat. Four tablespoons have the same nutritional value as a ripe medium-sized tomato.
- Research shows that most adults prefer mustard to ketchup, but kids prefer ketchup. Children under 13 eat 50% more ketchup than adults do.
- Americans consume an average of three bottles of ketchup a year.
- There are good and bad years for making ketchup, depending upon the quality of the tomato harvest.
- Ketchup made in the summer is often made directly from ripe tomatoes. In late summer, tomatoes are boiled down to make the paste used the rest of the year.
- Ketchup is mentioned in the literary works of Lord Byron, Jane Austin, and Charles Dickens.
- The world's largest ketchup bottle is actually a 170 foot tall water tower in Collinsville, Illinois. Collinsville was once the site of a ketchup bottling plant. The tower is a popular tourist attraction and even has its own fan club and web site.
- There has not been a ketchup factory in Collinsville since the 1960s. It is said that long-time residents miss the sweet smell of ketchup in the air.
- The most common consumer complaint regarding ketchup is difficulty in getting the sauce out of the bottle. People don't like having to wait, nor do they like shaking the bottle, the crust around the opening, or the difficulty in controlling where the ketchup goes when it finally comes out. Competition among ketchup manufacturers includes improvements such as easy grip, straight shooting, and vacuum action containers.
- The inventor of the squeezable ketchup bottle, Stanley Mason, also invented disposable contoured diapers, granola bars, dental floss dispensers, plastic microwave cookware, heated pizza boxes, and more.
- Ketchup got a lot of publicity in the 1980s when the Reagan administration, trying to save money on school lunches, declared it to be a vegetable. A further complication occurred when one company that had been using the spelling "catsup" found that only products labeled "ketchup" were included in the ruling. By the time they changed their spelling, public outcry had caused the administration to change its policy.
- A group of families snowbound on a mountain in South Africa were rescued after they used ketchup to write a huge red H in the snow.
- In 2002, "Las Ketchup," a group consisting of three Spanish sisters, became a huge hit worldwide with their song and dance "The Ketchup Song (Hey Hah)." Their style combines elements of rumba, Latin pop, reggae, and hip-hop.
- A group called The Corporation for the Advancement of Totally Stupid and Useless Projects (C.A.T.S.U.P.) says that its first project is the restoration of the "proper" spelling i.e., *catsup*. They also oppose acronyms that they consider to be worse than their own.

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- Ketchup can be used to polish copper utensils. The acid in the sauce removes tarnish.
- Former President Richard Nixon liked to put ketchup on his cottage cheese.
- In Japan, ketchup is often served over rice.
- An ice cream manufacturer once tried making ketchup ice cream. It was not a success.
- Sparkly ketchup was marketed in 1997. It wasn't successful either.
- Green ketchup was one of the first foods to be marketed in unusual colors. It was followed by such products as blue soda, blue vanilla pudding, green and blue filling in Oreo® cookies, hot pink margarine, green popcorn, and various colors of cereal, french fries, and macaroni.
- The next color for ketchup after the green version was purple. In the spring of 2002, one of the major ketchup companies produced one million squeeze bottles each containing pink, orange, or teal sauce. The buyers couldn't tell what color was inside until they used it. The company plans a similar mystery bottle in 2003.
- An unopened bottle of ketchup can be stored as long as a year if kept in a cool, dry place. Once opened, it will last about a month if kept cool. Ketchup stored in a warm location such as direct sunlight may ferment, causing it to spurt all over when the bottle is opened.
- The demand for ketchup was a major factor in passing the Pure Food and Drugs Bill in 1906.
- Tomatoes get their red color from lycopene, an organic chemical compound. Lycopene is an antioxidant, believed to be important in maintaining healthy cells. It may help prevent cancer and heart disease. Research has shown that the lycopene in processed tomatoes is more easily absorbed into our bodies than what we are likely to get from fresh tomatoes. However, the small amount of ketchup on a hamburger is not enough to make it a health food!
- Every so often, a rumor circulates claiming that ketchup contains pigs' blood. It doesn't.

Things to Do

- Purchase several different colors of ketchup. Survey the class to determine which is most appealing, and discuss the results. Have the students shut their eyes and taste each color to see if they can detect any differences. (Note: have students rinse out their mouths with water between each of the samples tasted.)
- About $13 billion is spent by the food and drink industries just to market their products to kids. Parents are strongly influenced by their children as to which products to buy, and kids from 12 to 17 are significant spenders themselves. Marketers found that kids generally like and want to buy oddly colored food. With this in mind:
  - Survey different age groups to find out which color(s) of ketchup they prefer, and compare the data.
  - Ask kids of different ages what the next new color of ketchup should be.
  - Go to a local grocery store and make a list of foods with unusual colors.
  - Use the Internet and other sources to research other products that come in unexpected colors.
  - Look for advertisements for strangely colored foods. Analyze the ads to determine the age group they target, what strategies are used, and whether or not they are successful.

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- Find out more about Stanley Mason, a prolific inventor.
- According to one researcher, the fastest speed at which ketchup can flow is 28 cm/min at 20°C (68°F). Design an investigation to prove, disprove, or perhaps surpass this observation.
- Make your own ketchup (see *Internet Connections).*
- Find out more about research regarding lycopene. Debate: could ketchup be considered a health food?

Literature Connections

Smith, Andres. *Pure Ketchup: A History of America's National Condiment, with Recipes.* Smithsonian Institution Press. Washington, DC. 2001.
A comprehensive and entertaining history, including ketchup-related anecdotes and recipes for over 100 varieties of ketchup.

Internet Connections

http://www.ketchup.wonderland.org/
Planet Ketchup: history, FAQs, recipes, just about everything you might want to know about ketchup (commercial site)

http://www.clearfour.com/condiment/ketchup.html
A museum collection of ketchup packages

http://www.foodreference.com/html/qcatsup.html
Ogden Nash poem about catsup

http://homecooking.about.com/library/archive/blcon13.htm
Banana, cherry, or mango ketchup? Ancho chile ketchup? Recipes for making and using unusual ketchups (commerical site)

http://www.cdkitchen.com/rfr/data/2002/1030282537.shtml
Recipes for mushroom, cranberry, anchovy, and other ketchups (commerical site)

http://www.lycopene.org/
Learn more about lycopene

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P. O. Box 8120
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